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Activities of the United Nations system in the field of water and mineral resources, and inter-agency coordination focusing on progress made towards achieving sustainable development

Technical cooperation activities of the United Nations system in mineral resources

Report of the Secretary-General

Summary

The present report, prepared in response to Economic and Social Council decision 1996/306, summarizes and describes the activities of United Nations bodies and the specialized agencies in the area of mineral resources. It covers activities with regard to, *inter alia*, the environment; issues related to the social and economic impact of the mining sector, especially in developing countries and economies in transition; and a global knowledge base on mineral resource potential.

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I. Introduction

1. The Economic and Social Council, in its decision 1996/306 and upon the recommendation of the Committee on Natural Resources at its third session (6-16 May 1996), adopted the provisional agenda and documentation for the fourth session of the Committee, which includes a report of the Secretary-General on the technical cooperation activities of the United Nations system in the field of mineral resources, to be submitted to the Committee at its fourth session. The Committee had recommended that the report focus on the basic problem of improving the capacity of developing countries and economies in transition to capture the maximum economic and social benefits of their potential for mineral production.

2. The present report assesses the technical cooperation activities of the United Nations system in the field of mineral resources undertaken since the previous report of the Secretary-General was issued (E/C.7/1996/7). That report paid particular attention to the changes made by the United Nations system in the field of mineral resources in response to Agenda 21.[1] It also discussed activities in mineral resource development in areas of privatization, investment promotion, and small-scale and artisanal mining.

3. The present report includes general comments from the Economic Commission for Latin America, the Economic Commission for Africa, the Economic and Social Commission for Asia and the Pacific, the United Nations Revolving Fund for Natural Resources Exploration and the United Nations Conference on Trade and Development.

4. The report is structured as follows: section II provides a brief summary of the activities of United Nations bodies in the field of mineral resources, reports on measures taken by the United Nations system in response to Agenda 21 and the Copenhagen Declaration on Social Development,[2] and describes the coordination and integration of activities. Section III describes activities in other areas of mineral resource development. Section IV discusses the global knowledge base on mineral resource potential. Section V covers current issues in mineral resource development and the focus of future activities, and offers conclusions and recommendations for the direction of future work for consideration by the Committee.

II. The United Nations system and mineral resource development

A. United Nations bodies participating in technical cooperation activities in the field of mineral resources

5. Within the United Nations Secretariat, the Department of Economic and Social Affairs is the principal United Nations office responsible for the implementation and coordination of technical cooperation activities in the field of mineral resource development. Also involved in the execution and finance of regional projects, through grants of technical cooperation assistance, are the following regional commissions: Economic Commission for Africa (ECA), Economic Commission for Latin America and the Caribbean (ECLAC), Economic and Social Commission for Asia and the Pacific (ESCAP) and the Economic and Social Commission for Western Asia (ESCWA). The United Nations Conference on Trade and Development (UNCTAD) is mainly concerned with mineral economics and trade in primary commodities, while its Programme on Transnational Corporations assists Governments in their relations with transnational corporations.

6. The United Nations programmes involved in technical cooperation activities in mineral resources, primarily in a financing capacity, are the United Nations Development Programme (UNDP), which finances technical cooperation activities in all aspects of mineral resource development; the United Nations Revolving Fund for Natural Resources Exploration, which was established to provide an additional source of exploration financing for countries not adequately covered by other sources, and the United Nations Environment Programme (UNEP), which finances mineral resource activities related to environmental protection.

7. The United Nations Educational, Scientific and Cultural Organization (UNESCO) provides assistance for formal academic training, the establishment of schools of geology, and certain research programmes. The United Nations Industrial Development Organization (UNIDO) assists in developing mineral-based industrial processing operations. The International Labour Organization (ILO) participates in technical cooperation relating to work conditions and worker safety in mineral resource extraction, encompassing all levels of mining. The International Atomic Energy Agency (IAEA) is involved in regulating and giving limited assistance for the exploration of nuclear raw materials. Finally, the World Bank and its affiliate, the International Finance Corporation, provide grants and soft

loans for technical cooperation activities and project financing.

B. Measures taken in response to Agenda 21 and the Copenhagen Declaration on Social Development

8. During its third session the Committee noted that special consideration needed to be given to sustaining the social and economic development of local communities after termination of a mining project. It also urged Governments to ensure participation in decision-making by all parties involved at each stage of mineral project development.

9. In light of the spirit of the Copenhagen Declaration, the United Nations bodies participating in the technical cooperation activities in mineral resources have reoriented their activities. Their reformulated policies place increasing emphasis on the sustainability of mineral development projects by actively promoting a constructive dialogue between communities, industry and Governments so that the interests of all stakeholders are taken into consideration and by emphasizing capacity-building and the training of those involved. At the same time, in implementing chapter 10 of Agenda 21, "Integrated approach to the planning and management of land resources", they have continued to place increasing emphasis on and give priority to environmental protection and to assist developing countries and economies in transition to develop their mineral resources using environmentally sensitive technologies.

C. Coordination and integration of activities

10. During the six years since the adoption of Agenda 21, in assisting countries to develop their mineral resources, the United Nations system has adopted a crosssectoral approach which integrates economic, environmental and sustainable development policies into all aspects of mining and mineral processing and utilization activities.

11. At the special session of the General Assembly to review and appraise the implementation of Agenda 21, held in 1997, Member States reaffirmed their belief that, if sustainable development was to become a reality through the integration of economic, environmental and social policies, the implementation of Agenda 21 in a comprehensive manner remained vitally important and was more urgent than ever. Agenda 21 emphasized the need for the adoption of environmental guidelines for natural resource development. Both the Natural Resources and Environmental Management Branch of the Department of Economic and Social Affairs and UNEP were requested by a number of developing countries to provide environmental guidelines for the mineral sector. UNEP and the Department jointly prepared and recently published "Environmental guidelines for the mineral sector" (ST/TCD/20).

12. The environmental guidelines for mining operations address regulatory frameworks, environmental impact assessments, environmental management agreements, environmental management programmes, environmental monitoring programmes, mine site rehabilitation, pollution control, recycling and waste disposal issues, mine site decommissioning, training, and corporate incentives. They include relevant examples of environmental management practices and regulations from various mining countries. (The examples necessarily reflect the legal and administrative contexts in the countries from which they are drawn.)

13. In the field of environmental management of mining operations, ESCAP and UNCTAD collaborated in the compilation of a regional study on environmental policies, regulations and management practices in mineral resource development in Asia and the Pacific. In cooperation with UNCTAD, two regional seminars were held in Indonesia and Viet Nam on major issues pertaining to the environmental management of mineral resources.

14. The Department of Economic and Social Affairs also collaborated with UNEP and Istanbul Technical University to convene an interregional seminar in Turkey to address the issue of community participation in the environmental management of tailing dams of previous metal mining.

1. Department of Economic and Social Affairs, United Nations Secretariat

15. With the increasing emphasis on implementing the goals of Agenda 21 and the principles of the Rio Declaration on Environment and Development,[3] the Department has been involved in the following activities in mining and the environment: drafting of environmental laws and policies for the mining sector, environmental regulations for small-scale mining, environmental education and raising awareness in local communities. Environmental management tools include environmental impact assessments, environmental audits, the promotion of conservation and recycling of mineral resources, and reclamation/rehabilitation and capacity-building for environmental management in relation to mineral development. The Department conducted a workshop/training programme on environmental management in the mineral resource sector in Mozambique,

at the request of the Government, at both the national and provincial levels. The workshop covered environmental management policies and tools such as environmental impact assessments, environmental audits, environmental monitoring, and evaluation and enforcement, which are important in furthering capacity-building. Participation in environmental planning and management is clearly mandated by Agenda 21, which unequivocally states that decisions should be taken as close as possible to the levels of society which they affect. In accordance with the Copenhagen Declaration, which reiterates the importance of governance through a participatory, transparent and accountable administration, the workshop addressed participatory approaches to all aspects of sustainable human development in the mineral resource sector and approaches to environmental problems in the mineral resource sector: command and control regulations, economic instruments, industry self-regulation, community regulations, and mixed approaches.

2. Economic Commission for Africa

16. In 1997 ECA began a study on productivity evaluation, environmental impact, and health and security risks of small-scale mining activities. The objective is to compare a number of countries in Africa and other developing regions with a view to making recommendations on guidelines and regulations related to environmental protection and restoration. The recommendations will form a basis for determining the models and instruments to be used by member States to promote sustained small-scale mining. The study is scheduled to be completed by November 1998. ECA has also continued to assist member countries in other aspects of small-scale mining, with particular emphasis on environmental issues. It has pursued its assistance to Equatorial Guinea by strengthening institutional and legal frameworks to increase the output of small-scale mines with less pressure on the environment. ECA prepared a study for the integrated development of the Liptako-Gourma region, including Burkina Faso, Mali and Niger. The study included a special chapter on environmental issues and made recommendations for promoting rational, artisanal and small-scale gold mining in the subregion.

3. United Nations Conference on Trade and Development

17. Several analytical studies have been carried out on the environmental management of mining, including four case studies on environmental management in the gold, bauxite and aluminum industries in Brazil, Ghana, Indonesia and Zimbabwe. A survey has been published on environmental legislation in selected countries in the Asia/Pacific region. A report, published jointly with ESCAP in 1997, summarizes the results of workshops on environmental management organized by UNCTAD in cooperation with ESCAP.

4. United Nations Revolving Fund for Natural Resources Exploration

18. From the viewpoint of the changing world of the mining industry and the role of the United Nations system therein, the United Nations Revolving Fund for Natural Resources Exploration will, in the area of environmental protection, focus on strategic workshops and research on environmental issues in order to clarify the role of the Fund and establish sound policy on mining-related pollution. It will also develop and implement projects for mitigating environmental degradation in mining-related pollution.

III. Activities in other areas of mineral resources development

A. Issues related to the social and economic impact of the mining sector, especially in developing countries and economies in transition

1. Economic Commission for Africa

19. ECA has addressed the problem of improving the capacity of African countries to capture the maximum sustainable economic and social benefits from their mineral resources in two areas: increased investment flows, and the promotion of effective cooperation in the sector. The issue of increased investment flows was considered in the global context of liberalization characterized by privatization. In 1996, a high-level expert group meeting was called to consider, on the one hand, the conditions under which the private sector could optimize its contribution to natural resources and energy development in Africa and, on the other hand, the legal and regulatory environment which would make the exercise beneficial to national economies and people alike. The experts identified essential criteria that should be taken into account in national policy-making so as to enhance private-sector participation so that privatization and deregulation could be effected in line with Africa's social and economic priorities. On the question of cooperation, the secretariat convened in November 1997 the second meeting of the regional Conference of African Ministers responsible for the Development and Utilization of Mineral and Energy Resources. The meeting, held in

South Africa, discussed the theme of strengthening cooperation among development partners in order to achieve sustainable development and use of mineral and energy resources in Africa.

2. Economic and Social Commission for Asia and the Pacific

20. At its fifty-third session in April 1997, ESCAP noted that the substantial increase in mining activities in the Asia and Pacific region, especially in the developing countries, had brought to the fore the social impact of mining activities on local communities. In the past, the exclusion of host communities from the planning process and from the economic benefits arising from mining activities and the environmental degradation resulting from such activities sometimes led to conflicts between host communities, Governments and mining companies. Issues such as disparities in socio-economic conditions between the mine workers and host communities, the transfer of skills to local people, and traditional land use practices are beginning to be addressed. The Commission noted the need for assistance to member countries in examining new policy directions for harmonizing mining activities with the aspirations of host communities. Although increased involvement of the private sector in mining should be encouraged, government should act as catalysts so as to ensure that all relevant issues are addressed.

3. United Nations Revolving Fund for Natural Resources Exploration

21. The exploration of minerals by the Fund will focus mainly on deposits appropriate for small-scale mining in the socially and economically less stable developing countries. The Fund intends to step in where private mining companies are not willing to explore in spite of high mineral potential.

4. United Nations Conference on Trade and Development

22. In recent years UNCTAD's work on the economic and policy analysis of mineral-related problems has focused on the economic development policies of mineral-dependent countries and on governance issues. The UNCTAD secretariat has prepared several studies on governmental policies aiming to enhance the contribution of the mineral sector to economic development in developing countries, assessing how the mineral sector influences and is influenced by the general macroeconomic environment. These studies, which influenced case studies on the Dominican Republic, Indonesia and Peru, were motivated by the disappointing economic performance of most developing economies with mineral deposits. In 1996, at the invitation of the Secretary-General of UNCTAD, an ad hoc meeting of experts carried out an in-depth review of economic policies in countries dependent on exports of goods based on natural resources. A report on the discussions was issued as an UNCTAD document; a fuller version will be published in 1998. UNCTAD has also carried out research and analytical studies on governance issues for the mineral sector, including aspects such as foreign investment regimes, the role of State-owned enterprises and privatization, and taxation systems for mining and environmental management for the mineral sector. A report published in 1997, "Management of commodity resources in the context of sustainable development governance issues for the mineral sector" summarizes UNCTAD's work.

23. A relatively new area of work is the relationship between the development of local communities and mining and the problems of how to integrate the concerns of all parties into regional development planning. UNCTAD organized a workshop on this subject in Indonesia in 1996. The proceedings have been published. UNCTAD intends to emphasize the management of commodity resources in the context of sustainable development and the social impacts of mining in all of its technical assistance activities. It is undertaking a major project on sustainable mineral development and local communities. The project aims to enhance the capacity of developing countries to address sustainable development issues when natural resources are exploited for commodity production. It is intended to:

(a) Devise a model framework to assist in the analysis and management of natural resource issues;

(b) Promote the use of the framework in individual developing countries with the support of national and regional institutions;

(c) Provide training on tools, techniques and methodologies to support a cooperative approach to sustainable development, involving all stakeholders, particularly local communities.

The training portion will focus on strengthening capacities for participation in decision-making. The objective is to provide the techniques and methods necessary to assist local and national agencies in the assessment of the environmental and socio-economic impacts of alternative strategies of resource management. A first pilot project has been initiated in South Africa, where UNCTAD is cooperating with the government of Northern Cape Province in exploring development alternatives for the Namaqualand region, which

is heavily dependent on diamond mining and which is faced with the exhaustion of diamond deposits in about 10 years.

5. Economic Commission for Latin America

24. Advisory missions were fielded to prepare legislation codes for mining, energy, water and marine resources. A comparative analysis of legislation on natural resources and energy of the region was carried out.

6. Department of Economic and Social Affairs, United Nations Secretariat

25. The Department of Economic and Social Affairs, in addition to being involved in the technical cooperation and capacity-building activities described above, is pursuing activities that seek to :

(a) Enhance the contribution of artisanal and small-scale mining to the economic and social development of local communities;

(b) Sustain the social and economic development of local communities after the termination of capital-intensive mining projects with a finite and relatively short operational life;

(c) Reform small-scale mining to formalize economic activities and increase their access to international financing institutions and multinational mining companies;

(d) Develop policies to identify the possible negative social impacts of privatization of State-owned mineral assets and innovative privatization plans to ensure the continuation of the economic and social functions performed by State enterprises;

(e) Redirect the profits from minerals development to economic and social benefits;

(f) Structure new community/corporation relationships for social development.

26. The Department has been active in conceiving and implementing projects in various countries seeking to harmonize socio-economic development with environmental protection. It has formulated a multidimensional strategy against poverty in Burkina Faso, centred on an integrated approach to small-scale mining development. The aim is to transform artisanal mining into an instrument of sustaining human development.

27. The Department presented a paper on the contribution of small-scale mining and energy to poverty reduction and perspectives for technical cooperation in Africa at the second Conference of African Ministers Responsible for the Development and Utilization of Mineral and Energy Resources, in November 1997. The paper dealt with methodologies for eradicating poverty and sustaining economic growth. In 1997, the Department participated in the Washington Roundtable on Mining: the Next 25 Years, which was convened by the World Bank. One of the main objectives of the Roundtable was to examine ways in which international development institutions might help promote sustainable mining development.

28. In 1997 the Department undertook a study on the socio-economic implications of privatization of State-owned mineral assets in developing countries. The study dealt with the impacts of privatization in some developing countries and suggests ways to reduce the negative impacts. The Department's paper on mining policies and the law in three Asian countries in transition, presented at the Conference of the Mineral Economics and Management Society, in Colorado in 1997, dealt with three countries in transition in which the mining sector plays an important role in the national economy. For both industry and government the primary challenge for the future will be how to privatize national mining companies and meet the needs of industry for profit and stability, while allowing Governments to acquire "adequate economic rent" from privatized development to ensure sustainable development for its citizens. The paper underscored the importance of a new tripartite partnership between government, industry and community. The Department organized a symposium in May 1996 on corporations, communities and sustainable social development which brought together the private sector, government representatives, non-governmental organizations and international organizations to examine specific experiences in the mineral sector. The Department also convened a meeting with the representatives of large mining companies and non-governmental organizations in February 1997, which highlighted future areas of public/private partnership in mineral development and sustainable human development. It was decided that the Department would collaborate with the private sector and local communities to carry out the case studies on Government/industry interface in the mining sector which the Department has recently initiated.

29. The advisory services of the Department focused on the formulation and implementation of national environmental policies and laws (in Mozambique and Cameroon) which maximized the contribution of the private sector through economic incentives and instruments and the participation of non-governmental organizations and local communities in monitoring and implementation. The advisory services to Governments relate to the special needs of small-scale mining and mining in the informal sector and

integrating women into all aspects of the mineral development process and related training processes. In the area of natural resources the Department has collaborated with the United Nations Development Fund for Women (UNIFEM) to promote gender-sensitive approaches to mineral resources management. It participated in the workshop for women small-scale miners, held in 1996 in Zimbabwe, which resulted in the creation of the Women's Miners Association of the South African Development Community.

30. Capacity-building in the natural resources sector is being addressed by the Department in several ways:

(a) Assisting developing country Governments to initiate formal institutional capacity for the integrated management of mineral resources by women and other affected communities;

(b) Drafting new mining/petroleum laws for developing countries and building capacity in monitoring and enforcement by the relevant agencies and institutions;

(c) Developing enabling mechanisms for full and effective participation by local communities in the sector at all stages of a project;

(d) Utilizing national expertise for project implementation, keeping in mind that local capacity is the key to sustainable social development;

(e) Holding workshops/training programmes at both national and provincial levels for those engaged in small-scale mining and artisanal mining activities in the use of environmentally sound technology.

B. Technical cooperation activities

31. The Department's other technical cooperation activities include a mineral sector development project in the Lao People's Democratic Republic, which is now being successfully completed. The overall objective of the project is to promote the development of the country's mineral sector in an environmentally sound manner by strengthening the geological survey and the mining concession divisions, thereby contributing to national economic growth. The project has resulted in improvements in the technical and professional capacity of the country's geo-science.

32. In India, a project for the development of the gemstone resources of Orissa state has recently been completed. The project aimed at assessing the gemstone prospects of Orissa; optimal recovery of the stones, through appropriate mining and processing techniques; establishment of a modern gem-testing laboratory; and upgrading the knowledge, skills, and expertise of the host Government's technical personnel via training in state-of-the-art techniques.

33. Another project in India involves the establishment of a mineral processing laboratory at Nagpur. The project aims to accelerate the expansion of India's mineral industry through the application of improved technology for the recovery of minerals from complex and low-grade ores.

34. The Government of Chad, with the support of UNDP and the Department, has promoted the development of the country's mineral sector. Laboratory equipment for gold analysis and training of nationals in its use were provided. In addition, a workshop in contract negotiations was organized in December 1997.

35. In Niger the results of a recently completed project were the following:

(a) Production of a geological and metallogenic map and an aerial geophysical survey over 4,750 square kilometres, and dissemination of information on gold deposits in the Liptako area;

(b) Fully equipped government services for mineral exploration and training of staff in the use of equipment;

(c) Modernization of a laboratory for chemical analyses;

(d) Organization of an international round table for the promotion of the gold potential of the Liptako area. After the round table was held, 13 mineral agreements were signed with multinational companies.

The Ministry of Mines, Industry and Technology is now capable of formulating a rational mineral development plan and programming mineral exploration in other areas of Niger.

36. The Department has also carried out extensive technical cooperation activities to upgrade the minerals sector in the Atakpame region of Togo. The work led to the discovery of valuable mineral deposits and to mineral concessions awarded to private companies. The Department is also assisting the Government of Mali in a project to promote and develop small-scale mining activities and to train nationals in environmental protection. In particular, the project is aiming at reducing poverty, creating employment, managing natural resources and the environment and integrating women into the development of the country.

37. The Department is supporting a project in Fiji to help establish a viable mining industry. The Government seeks to strengthen its institutional capacity to manage all aspects of the mineral sector, including how to avoid adverse

environmental consequences. The Department had fielded a resource policy adviser to Fiji who will provide the impetus for the establishment of a mining development coordinating unit, with particular emphasis on the Namosi project, and develop long-term strategies for the mineral section.

1. Economic and Social Commission for Asia and the Pacific

38. ESCAP continued to assist the developing countries and economies in transition in the region, especially those in Indochina, North-east Asia, and Central Asia, in the assessment and development of mineral resources, in particular in policy reorientation and institution-strengthening for the promotion of foreign direct investment (FDI) in exploration, mining and mineral-based industries. The secretariat provided advisory services to the Governments of Armenia, Azerbaijan, Bangladesh, Cambodia, Kyrgyzstan, Lao People's Democratic Republic, Mongolia, Myanmar, Nepal, Pakistan, the Philippines, the Islamic Republic of Iran, Solomon Islands, Sri Lanka, Vanuatu, and Viet Nam to review legal and fiscal regimes and related regulatory and institutional frameworks for enhancing FDI flows and to identify major exploration targets for the assessment and development of commercially exploitable mineral deposits.

2. United Nations Conference on Trade and Development

39. As part of its technical assistance programme, which is funded by contributions from UNCTAD member States and UNDP, UNCTAD organizes training courses, particularly in the areas of governance, environmental management, socio-economic impacts of mining and risk management for minerals and metals industries. Several courses are provided each year.

40. In order to support its training programmes, UNCTAD intends to publish a manual on mining, the environment and development in the first half of 1998. The manual, which will also be issued as an UNCTAD publication, will deal with international aspects of mining, including international law and the nature of the international mining industry, national policies and the environment.

3. United Nations Industrial Development Organization

41. In recent years UNIDO has been involved in activities that are focused on environmental concerns in artisanal and small-scale mining. The subsector provides the means of subsistence to a larger number of people than does formal large- and medium-scale mining worldwide. As a result, with a few exceptions, artisanal gold mining is haphazard, unregulated and environmentally unsound, especially because of the excessive use of mercury and the release of toxic metal into the environment. UNIDO's assistance in avoiding mercury pollution has been requested by more than 10 developing countries. Programmes addressing the issue of mercury pollution have been prepared by UNIDO for Chad, Cameroon and the Philippines. An expert group meeting for developing strategies to combat mercury pollution emanating from artisanal mining was held at UNIDO headquarters. A project focusing on the training of government officials, the offices of mining associations and artisanal miners is currently under way in the United Republic of Tanzania. Furthermore, assistance was provided to Namibia in the implementation of its mining code.

IV. Global knowledge base on mineral resource potential

A. Economic Commission for Africa

42. ECA made a firm decision to use new information technologies under the African Information Society Initiative. The secretariat's objective is to help member States to locate, from the flow of information available, information and data on mineral resources. ECA is also, in consultation with regional economic groupings and intergovernmental institutions, promoting the organization of member States' databases into subregional and regional networks.

43. To facilitate the sharing of information and data, the following are being published: a biannual information newsletter on mineral resources and energy; a statistical annex on mineral resources and energy production and consumption patterns, to be utilized by the *African Economic Report*, published annually; and a biannual survey on economic and social conditions in Africa. It is expected that issuance of up-to-date information and data, on a regular basis, will facilitate the sharing of information and experience among African countries and also generate greater international awareness of developments in the African mining sector.

B. United Nations Conference on Trade and Development

44. The main publication of UNCTAD in the field of information on minerals and metals is the annual *Handbook of World Mineral Trade Statistics*, which includes data for all countries on imports and exports of the 15 most important metals, from ores and concentrates to semi-fabricated products, and on the 12 most important non-metallic minerals. It also includes summary tables on total world trade in minerals and metals and the value of mineral production. The *Handbook* is based on national statistics, which the UNCTAD secretariat reviews in order to ensure consistency of definitions and eliminate errors. The 1997 issue, containing data up to and including 1996, was published in December 1997. UNCTAD also produces the monthly *Commodity Price Bulletin* which includes price data for the most important metals.

45. UNCTAD also produces reviews of industry and market developments regarding individual minerals and metals. A number of studies were prepared in 1996 on the implications for the aluminum, copper and nickel markets of the outcome of the Uruguay Round. A review of changes in production capacity for bauxite, alumina and aluminum is prepared on an annual basis. In addition, reviews of developments in the market for iron ore are published twice a year under a trust fund project financed by several member Governments and the European Union.

46. In order to contribute further to the dissemination of high quality information concerning the minerals and metals industries, UNCTAD is launching the Mineral Resources Forum in early 1998. The Forum will be an Internet Web site designed to promote and enhance the role of mineral resources in sustainable development. It will provide access to information in 12 subject areas, including economics, environment, investment and statistics, and will contain news, documents, library catalogues, discussion groups and references to related Web sites.

C. Economic and Social Commission for Asia and the Pacific

47. Continuously since 1985, ESCAP has carried out activities to identify the mineral resource potential of the region. The following countries have been studied under the ESCAP mineral atlas series: Afghanistan, Bhutan, Cambodia, Kyrgyzstan, Lao People's Democratic Republic, Malaysia, Mongolia, Myanmar, Nepal, New Zealand, Republic of Korea, Solomon Islands, Sri Lanka and Viet Nam. Booklets in the series are accompanied by small-scale (1:1,000,000-1,500,000) geological and mineral distribution maps and contain a broad overview of major tectonic and structural units and a description of their stratigraphy, magmatism and associated metallogeny. They provide information on mineral deposits and occurrences, either metallic or non-metallic; distribution patterns; geographical location; contained commodities; and reserves and their relation to their geological environment and other characteristics. The most recent booklets contain an overview of the current state of the mining industry and the regulatory governmental framework for the development of the mineral sector and an index of mineral deposits and occurrences. UNCTAD also publishes commodity studies on fertilizer minerals, oil and gas, tin, tungsten, mineral sands, industrial minerals, epithermal gold and base metal mineralization.

48. Knowledge of mineral resource potential at the subregional level ranges from the geological perspective, the status of systematic geological mapping and mineral exploration programmes to the maturity of the mining industry and governmental policies on access to data. Information on regional and subregional resource potential is generally collected by Governments through their participation in mineral-related conferences, meetings and forums convened by United Nations agencies, intergovernmental organizations and the private sector.

49. ESCAP is planning to conduct two subregional projects on mineral resources assessment, using GIS for the countries of North-east Asia and the Greater Mekong region.

50. The Workshop on Sustainable Minerals Supply in the Asia and Pacific Region, held in Bangkok in November 1997, recommended that ESCAP, in conjunction with the International Trade and Commodities Division of UNCTAD, should convene two workshops – one for formulating regional, bilateral or multilateral policy initiatives for enhancing trade and development in minerals and mineral-based products; and one on the establishment of a standardized format for the classification and reporting of mineral occurrences, resources and reserves for the Asian/Pacific region. Also, in conjunction with the International Trade and Commodities Division of UNCTAD, ESCAP should convene a seminar on the non-metallic mineral-based industries and trade for the Asian/Pacific region. The workshop also urged ESCAP to act as a focal point for disseminating information on non-metallic mineral-based industries and on research and development among the relevant organizations in member countries, and to assist member countries in conducting national training programmes for governmental officials to improve their

capabilities in negotiating mineral investment agreements with the private sector.

V. Current issues and recommendations

51. Since the United Nations Conference on Environment and Development, and its adoption of Agenda 21, and the World Summit on Social Development, and its adoption of the Copenhagen Declaration and Programme of Action, the United Nations system has increased its emphasis on the formulation and implementation of environmentally sound mineral development policies and adopted a cross-sectoral, multidisciplinary approach in coordinating and integrating technical cooperation activities into mineral resources development, particularly upstream technical support services.

52. The United Nations system continues to provide technical cooperation assistance and advisory services of a professional, impartial and non-commercial nature in the field of mineral resources, at the request of Member States. However, its ability to do so has been severely curtailed by current budgetary reductions, the financial situation in the United Nations Secretariat and significant changes in the funding of technical cooperation activities.

53. However, within the constraints of the limited resources available, several new areas and issues have assumed significance and are being addressed. The privatization of State-owned enterprises in the minerals sector has given rise to the need for sustainability of the social development functions being performed in the past by such enterprises. Privatization policies have produced lopsided imbalances in the energy sector (with an overemphasis of private-sector presence in energy-sector utilities) and the minerals sector (with a similar overemphasis on large-scale mining and on the extraction for export of a limited range of minerals). This has given rise to a need to address issues of privatization of small-scale mining activities and the need to encourage increased involvement in infrastructure, manufacturing and industry on the part of the private sector which utilizes the minerals and energy resources extracted within the country. It is becoming increasingly evident that privatization, *ipso facto*, is far from a panacea for the environmental consequences of minerals development. Hence the issue of internalizing environmental costs in minerals development activities has resurfaced, with new complexities arising as a result of privatization, deregulation and globalization.

54. Problems of sustaining social development activities funded out of revenues from mining, beyond the life of the mine and the orebody, are assuming increasing significance. Social disintegration, social unrest and internal armed conflicts are resulting from the failure to address the poverty, social and economic deprivation and environmental degradation resulting from mineral development activities, especially in developing countries where ethno-nationalism can tend to fuel fierce and tragic conflicts over resources. Corporations are being assigned increasingly important roles in social development, giving rise to the need to evolve new tripartite relationships between Governments, corporations and communities. The Committee may need to take note of these new issues and concerns and recommend ways to refocus cross-sectoral, multidisciplinary activities and alternative approaches to minerals resource development in an environmentally sustainable manner, given the current budgetary constraints under which United Nations organizations are operating and pursuant to their specific mandates.

Notes

[1] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992*, vol. I, *Resolutions Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigenda), resolution 1, annex II.

[2] *Report of the World Summit for Social Development, Copenhagen, 6-12 March 1995* (United Nations publication, Sales No. E.96.IV.8), chap. I, resolution 1, annex I.

[3] *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992*, vol. I, *Resolutions Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigenda), resolution 1, annex I.

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State-of-the-art environmental technologies for the utilization and reprocessing of mineral industry wastes

Report of the Secretary-General

Summary

The present report has been prepared in response to Economic and Social Council decision 1996/306. The report describes the utilization and reprocessing of mineral wastes within the larger context of the increasing uptake of source reduction technologies. Emphasis has been placed on solid wastes arising from the extraction and processing of base and precious metal ores since such wastes are responsible for some of the most intransigent and persistent environmental impacts. However, where relevant, examples from other mineral industry sub-sectors are also presented. Although the report focuses on mineral industry wastes, some of the technologies and practices reviewed may also be applicable to contaminated soils and other metal-bearing solids.

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I. Introduction

1. The availability of rich geological resources in tandem with market conditions largely outside the control of the metal-producing enterprises have resulted in a sector characterized by a low level of technological innovation. However, the emphasis has now altered: after a period of limited technological change, a spur to technology development in the minerals industry has been applied by public concern over adverse environmental effects and the design of environmental regulation that obliges firms to mitigate or prevent such effects. The dominance of "waste management" as opposed to "pollution prevention" at the present time is perhaps a reflection of the prevailing attitude towards closure, namely that a civil engineering-style remedial approach is sufficient to properly decommission a site and avoid possible liability in the future. But although that may have been true 20 years ago, technology, legislation and the expectations of stakeholders have changed since then, and if there is a generic thread that links current waste management approaches, it is the possibility of future litigation and liability associated with what might be considered short-term (but relatively cheap) solutions to long-term environmental problems.

II. Waste production in the mineral industry and related issues

2. Metals and other mineral resources are rarely found in a sufficiently pure state to be sold in an "as-mined" form. Metals are often found in chemical combination with oxygen (as oxides), sulphur (as sulphides) or other elements (chlorides, carbonates, arsenates, phosphates etc.). Non-metal mineral resources (coal, industrial minerals) also normally contain physically or chemically entrained impurities in their undisturbed state.

3. Although any unit operation within the life cycle of a mining operation has the potential to produce an environmental effect or impact, typically the potential arises from the deliberate (regulated) and accidental (non-regulated) discharge of solid, liquid and gaseous waste products. The characteristics of such discharges, the nature of the receiving environment and the distance over which the discharges are transported are major factors in determining the magnitude of their effect or impact. Societal values and preferences also play a significant role in determining how certain discharges are viewed by various stakeholder groups: this more subjective adjunct to the quantifiable and measurable discharge and receiving environment characteristics therefore sets, in part, the site-specific environmental "footprint" of an operation.

4. Increasingly, based on a more thorough understanding of the potential impacts, the pressure for environmental protection may outweigh the justification for exploiting particular mineral reserves (Hodges, 1995). The industry as a whole, in partnership with the broadest possible spectrum of stakeholders, must strive towards ever higher levels of performance in control and management of the mining process throughout the life cycle of an operation. This includes moving to an improved level of efficiency in resource utilization.

5. The major source of solid waste from mining and subsequent processing is "gangue" (valueless or sub-economic minerals associated with the target or economic mineral(s)). Depending on the point at which they are rejected from the process, gangue may be disposed of in an as-mined state (waste rock), as tailings (following mineral processing), as slags (after smelting) or as other waste products (dusts, sludges from water treatment, spent ore from leaching etc.). These various wastes may also contain significant quantities of the target mineral or metal due to inefficient processing, technological limitations or mineralogical factors.

6. There is also a trade-off between grade (the concentration of metal(s) in the final or intermediate product) and recovery (percentage of the total valuable metal(s) contained in the feed to the processing plant resulting in saleable product). It is possible to maintain a very high grade by rejecting a significant fraction of the input material (i.e., by accepting low recovery) or a very high recovery by excessively diluting concentrates with lower grade material. However, neither of these two extremes is normally the optimum economic solution. In simple terms, this is gauged by comparing the revenues generated by additional recovery of metal(s) against the capital and operating costs of doing so, within the greater context of technical feasibility. Without exception, some part of the target metal(s) will end up as waste, along with the gangue minerals.

7. In non-ferrous metal mining, gangue is normally the major component of an ore body. Nowhere is this more apparent than in the case of gold, where the concentration of valuable material is so low – normally 5 grams or less per ton – that effectively all of the mined ore is disposed of as waste in some form unless other valuable components, such as base metals, are also present. Other mineral resources may have less gangue relative to the target mineral, but disposal of gangue-related wastes normally remains a significant

issue, and many mining operations are as much about waste disposal as they are about resource extraction.

8. Evidently, the process of waste disposal related to mining activity is a significant source of potentially harmful elements in the natural environment. However, inputs do not necessarily result in damage to the environment; many mitigating factors may exist, some related to the process such as the chemical and physical characteristics of wastes, and others related to the external environment, such as climate, topography or ecosystem characteristics.

III. Utilization and reprocessing

9. Utilization and reprocessing are two of a range of "end-of-pipe" or "remedial" techniques for addressing the environmental issues associated with waste production in the mining industry. Historically, low-tech end-of-pipe approaches have dominated in the mining sector, but more recently these solutions have become increasingly sophisticated, against a background of the increasing application of "source reduction" technologies.

10. In the waste management "hierarchy" for dealing with wastes, utilization and reprocessing are less desirable than source reduction (pollution prevention) but a better environmental option than treatment or disposal (Allen and Rosselot, 1997).

11. Utilization normally entails the use of waste in an untreated form (although the physical form of the material may be adjusted); in the case of mineral industry wastes, utilization may be more feasible after reprocessing to remove or reduce the concentration of environmentally significant contaminants and target metal(s). Only those wastes that are sufficiently "clean" should be used, particularly off-site, since the major issue with waste utilization is the potential of dispersing environmentally harmful contaminants over a much wider spatial area. Generally, as the degree of contamination increases, so the potential for utilization decreases. Given those constraints, utilization may be equally attractive for current operations and for older or abandoned wastes.

12. The opposite could be said to hold for reprocessing, in that as the level of target metal(s) increases so the potential for reprocessing may increase. The concept of reprocessing to recover one or more valuable products (metal, metal salts, minerals) has a greater application in older waste outputs from the mining industry. There are two main reasons for this: in the past, ore grades were generally higher than those today and technology was less efficient.

13. Reprocessing may not necessarily result in environmental improvement, for example in cases where the residual waste (after reprocessing) still contains significant concentrations of other contaminants, such as non-target minerals. However, in many regulatory frameworks, reprocessing may be linked to safe disposal of the final waste (e.g., at an engineered disposal site) where this was not the case prior to reprocessing activity.

IV. Drivers affecting waste utilization and reprocessing

14. There are many "positive" drivers motivating innovative approaches to the remediation of contaminated mining sites, such as waste utilization and reprocessing. There are also many impediments ("negative" drivers) to the increased uptake of such approaches. Key positive drivers include technological advances; increasing metal prices; commodity scarcity; changes in strategic uses of certain commodities; maximization of resource utilization; Agenda 21; sustainability; the necessity of decoupling economic growth and environmental impacts; the polluter-pays principle; legal obligations/liabilities and bonding requirements; and other diffuse stakeholder pressures.

15. The perception of the general public that current approaches may be neither optimal or environmentally acceptable in the medium and long terms may also be significant, although that driver is probably felt less keenly in the mining industry than some other industrial sectors. Nevertheless at the local and regional levels it may still be significant.

16. Other drivers include regulatory frameworks that promote innovation in technology and resource management, and industry initiatives to develop more effective and lower-cost solutions to existing and future environmental issues (Kovalick, 1993; Ayen, 1994).

V. Mining (extraction) and potential wastes

17. In broad terms, there are three types of mining: surface, underground and *in situ* (solution mining). The latter is somewhat limited in its application, although it is sometimes used to exploit residual mineralization as grades drop at surface or underground mines. Surface mining is dominated by open pit (base and precious metal ore extraction) or open cast (coal operations) methods.

Irrespective of the method employed, mining is always accompanied by processing of some description. For relatively pure or homogeneous materials, processing may be limited to crushing and sizing (some natural zeolite extraction, quarried rock) or physical washing (some coal operations).Such simple processing options are only possible where the target minerals form the majority of the material extracted. In those cases, the main environmental releases, effects and impacts are associated primarily with the mining itself rather than with subsequent processing.

18. The two major releases from surface and underground mining relevant to reprocessing and utilization are mineral wastes (overburden and waste rock) and contaminated waters (acidic, metal-laden discharges from waste disposal sites and workings). The latter is also of importance at *in situ* mining operations, although the added chemical(s) by which the process of metal leaching takes place can also contribute to water contamination and pollution.

VI. Mineral processing and potential waste generation

19. Mineral processing is defined as the physical processing of minerals. It does not result in any chemical changes to the mineral components of the ore but is a means of achieving the physical separation (and concentration) of different mineral phases, such as the separation of target minerals from gangue minerals or of one valuable mineral from another (Hayes, 1993). For non-metal mineral resources, mineral processing can produce a final product, but in the case of metals it is an intermediate stage since it does not affect the chemical combination of the metal with oxygen, sulphur and so on. Mineral processing is normally an intermediate stage between mining and extractive metallurgy, although there are exceptions, such as heap and dump leaching of as-mined ore. The outputs from mineral processing (concentrates) form the inputs to extractive metallurgy (either hydrometallurgical or pyrometallurgical processes, see paras. 24-31 below).

20. Mineral processing methods can be divided into two groups: size reduction and separation of mineral phases. Crushing and grinding (in tandem with sizing) are used to liberate economic and non-economic minerals from one another, thereby producing suitable feeds for subsequent processes in which separate mineral phases can be generated. However, grinding does not normally produce a completely liberated mineral product, and some particles may be a mixture of two or more mineral species, with physical or chemical characteristics representative of that mixture. This can result in target minerals being disposed of with gangue minerals, or the dilution of the mineral concentrate by gangue minerals.

21. Size reduction is undertaken using "crushers" (jaw, gyratory and cone crushers) and "grinding mills" (rod, ball, hammer and impact mills). Crushing is used to reduce incoming ore from boulder-size down to a diameter of 25 millimetres or less. This material may then pass to grinding mills or may be processed directly if the valuable mineral is sufficiently liberated. Grinding reduces particle size down to a lower limit of about 10 microns.[1] In contrast to crushing, which is carried out on run-of-mine ore, grinding is almost always done wet and the output from grinding is a "slurry", a suspension of fine particles in water.

22. Mineral separation can be achieved by employing differences in mineral characteristics based on particle size, particle density, magnetic properties, electrical properties or surface chemistry (flotation).

23. The separation technique of choice is based upon a number of site-specific factors, including the size of the operation, the particle size at which minerals are sufficiently liberated, mineralogy, the overall processing circuit (from mining to extractive metallurgy) and so on. Ultimately, each process produces a "concentrate" (rich in the target mineral or minerals), "tailings" (containing mainly sub-economic or non-economic minerals) and "middlings" (particles in which target and gangue minerals have not been fully liberated). Middlings are normally reground or sent to an alternative process to liberate or otherwise recover the valuable mineral, while tailings are disposed of as waste. Of the various separation processes, flotation is now the dominant method for the production of mineral concentrates, particularly from sulphide ores, and is the major source of tailings. Other unit operations within mineral processing are of limited interest in terms of their potential to impact the external environment because they mainly operate within what are effectively closed circuits, i.e., many unit operations pass 100 per cent of their input to the next process. Flotation is often the final unit operation and the stage at which wastes (tailings) are generated and transferred to the external environment. Tailings generated during flotation are mainly composed of fine particles of gangue minerals, within which are contained varying amounts of the target mineral(s), depending on process economics, process efficiency and mineralogical constraints.

VII. Extractive metallurgy and potential waste generation

24. Extractive metallurgy can be subdivided into two major disciplines, "hydrometallurgy" and "pyrometallurgy". A third discipline, "electrometallurgy" is not considered here in depth because its use is more limited in the mining sector (mainly for the production of aluminium and some zinc).

A. Hydrometallurgy

25. Hydrometallurgical methods of ore treatment are most commonly used for gold, uranium, copper and aluminium, and to a lesser extent zinc and nickel. In particular, ores containing oxide material (about 10 per cent of non-ferrous ores) are treated by leaching. Ore is first processed according to the requirements of the subsequent processes, and a leaching agent is then used to extract the valuable metal(s) in the form of a dilute, metal-laden solution. This solution then passes to the metal recovery stage, which may involve precipitation, solvent extraction (SX) or electrowinning (EW).

26. Leaching reagents and solvents commonly used include:

(a) "Acids" (hydrochloric acid, sulphuric acid) for oxidized copper minerals, such as azurite, malachite, tenorite and chrysocolla, and "oxidants" (ferric sulphate) for less oxidized copper minerals, such as chalcocite, bornite, covelite and chalcopyrite;

(b) "Alkalis" and "ammonia-based" reagents (sodium/ammonium hydroxide or carbonate) for certain copper minerals;

(c) "Bacterially mediated" leaching, using bacteria to cost-effectively generate acid and oxidants from sulphide minerals;

(d) "Cyanide" (as a sodium or potassium cyanide solution) to dissolve gold;

(e) "Mercury" as an amalgamating reagent in the recovery of gold; it is widely applied at small-scale mining operations, principally in developing countries.

27. The methods used to deploy the above-mentioned leaching reagents include:

(a) "Dump leaching" of material on an unlined surface. The term derives from the practice of leaching materials that were initially deposited as waste rock; however, it is also applied to run-of-mine, low-grade sulphide or mixed-grade sulphide and oxide rock placed on unprepared ground specifically for leaching;

(b) "Heap leaching" of low-grade ore that has been deposited on a specially prepared, lined pad constructed using synthetic material, asphalt or compacted clay. In heap leaching, the ore is frequently pre-treated using size reduction (crushing) prior to placement on the pad;

(c) "Vat leaching" as a high-production rate alternative to heap and dump leaching, conducted in a system of vats or tanks using concentrated lixiviant solutions and run-of-mine ore/mineral concentrates.

28. The procedure for metal recovery varies with the metal, but often involves preferential cementation (copper or gold) SX/EW (copper).

29. Wastes generated during hydrometallurgical processes relevant to reprocessing and utilization include:

(a) "Spent ore/depleted concentrate", containing residual process chemicals, target and non-target minerals/metals;

(b) "SX-EW sludge", containing materials that can accumulate in solvent extraction/electrowinning tanks (particulates, emulsion of organic and aqueous phases);

(c) "Spent electrolyte" generated during electrowinning activities and laden with soluble impurities;

(d) "Mercury-contaminated wastes", resulting from the use of mercury in amalgamation.

B. Pyrometallurgy

30. Pyrometallurgical processes are currently the backbone of recovery for copper, zinc, nickel and lead from sulphide deposits. The process routes typically include mineral processing (normally flotation) to produce a concentrate, followed by smelting, which breaks down the crystalline structure of the minerals by heat-fuelled oxidation. The process for each metal or suite of metals is different. For example, copper smelting produces a "matte" (containing up to 40 per cent metal content), which in its molten form is converted and separated into "blister" (about 97-99 per cent pure) and an iron-silicate slag, which may have sufficient economic value to be worth further processing. Since blister metal is too impure for most industrial applications, refining is necessary. This is usually undertaken by a fire process (using a reverberatory furnace) if the feed has a low by-product content, or by electrolysis if additional metals are to be recovered. The resulting cathodes, which are usually about 99.8-99.9 per cent pure,

are marketed directly to the semi-fabricators or cast into shapes (wire bar). Lead, however, is produced via a route based on sintering, reduction of the sinter in a blast-furnace and pyro- or hydrometallurgical refining of the bullion.

31. Pyrometallurgical processes give rise to five potentially polluting products: waste gas, fugitive gas, effluents, smelter dust and slags, of which the latter two are of greatest significance in relation to reprocessing and utilization.

VIII. State of the art in mineral waste utilization

A. Constraints in mineral waste utilization

32. There are relatively few examples of mineral waste utilization in the base and precious metals mining industry. There are two main reasons. First, a constraint is placed on utilization by the presence of minerals (metals) that have the potential to cause environmental damage. Utilization in these cases can be viewed as a dispersion pathway and causative agent in wider environmental contamination and pollution. The second constraint is the high place value of the mineral wastes, even if "free" of contaminants. Transport costs outside a relatively limited area are likely in most cases to far exceed the saleable value of the waste itself. An additional constraint is the relatively low cost of primary materials with which the wastes compete (primary and secondary aggregates, other fill material etc.).

B. On-site utilization

33. The first and second constraints outlined above can be circumvented to a large extent by developing on-site uses for the wastes. This is already done to a large extent at most mining sites, and wastes are used in such applications as bunding, road building and maintenance, and in geotechnical applications. However, the largest potential on-site use of waste is as backfill, particularly for underground mines. Once again, however, the issue of contaminants and possible dispersion once the waste is in place arises, and it is common to backfill the waste with Portland cement, pulverized fuel ash or other stabilizing agents (soluble silicates), both to improve its physical characteristics and to minimize the potential leaching of metals into groundwater. Backfill of wastes is widely used in shallow underground mining operations (coal, limestone).

34. Minor and probably site-specific applications in the future may include water treatment, such as the use of finely ground waste rock as an adsorption material for flotation collectors (Heiskanen and Yao, 1992) and the use of pyrite (recovered via reprocessing; see sect. IX below) to remove dissolved arsenic species by adsorption (Zouboulis et al., 1993).

C. Off-site utilization

35. Toivola and Toivola (1997) have a patent for a method of producing a building material from a mixture of unscreened thermoplastic waste and mineral aggregate. Possible applications include paving slabs, bricks or concrete-style blocks. Aljaro (1991) reported the use of untreated tailings effluent as an agricultural water source, based on a study funded by the Corporación Nacional del Cobre de Chile in Chile. Untreated effluent has been used from the El Teniente copper-molybdenum mine to irrigate crops and water livestock. Crops that were tolerant of higher levels of copper, molybdenum, manganese and sulphates (and to local soil and water conditions) were identified and planted. Translocation of the metals to edible parts of the crops was limited and did not exceed allowable levels. However, due to the potential for build-up of metals in soil and groundwater, this use is likely to be very limited. Other uses that have been documented include large volumes of clean taconite tailings used as embankment, dam and highway materials in the United States of America, low volumes of clean taconite tailings used for ceramic, brick and tile production, and base and precious metal wastes used in dense calcium silicate bricks, aerated concrete, lightweight foamed building products, dry pressed bricks and glass (Mitchell, 1990).

IX. Mineral waste reprocessing

A. Reprocessing of wastes to recover acid generating sulphides

36. Partitioning of wastes into sulphide-rich and sulphide-depleted fractions offers the chance to expand waste management options for current operations, and to address environmental issues at sites where acid generation from non-segregated wastes is occurring. In both cases – theoretically – the low-volume sulphide-rich fraction can be disposed of at highly engineered disposal sites or isolated as buried "cells" within the bulk waste, while the high-

volume sulphide-depleted fraction can be disposed of as inert waste or utilized on- or off-site.

37. In a recent paper, Humber (1995) analysed the relationship between sulphide (pyrite and pyrrhotite) recovery, acid generation and operating/capital cost estimates for reprocessing. Several mineral-processing techniques were examined for their capacity to separate acid-generating sulphides from existing mill tailings and to generate a sulphide-depleted fraction and a low-volume sulphide-rich fraction. Methods examined included gravity separation (centrifugal concentrator, shaking table, spiral concentrator), flotation, magnetic separation and cyclone classification. These were tested on samples from three mines. The sulphide concentrates were also examined in terms of commercial value.[2] For each of the three samples, the sulphide minerals were well liberated and present at sufficiently low concentrations to produce (theoretically) a low-volume sulphide concentrate. None of the gravity methods attempted produced non-reactive (with no net capacity for acid generation) tailings. Flotation was more successful, although to a certain extent this appeared to reflect the simple nature of the mineralogy and the fine size distribution of the sulphides. Reprocessing via flotation not only reduced the capacity for acid generation in the depleted fraction but also reduced the concentration of other environmentally significant metals, such as cadmium, copper and zinc.

38. Based on the tests that generated wastes with the lowest potential for acid generation, operating and capital costs were estimated. Total capital costs ranged from $130,000 to $1,275,000. Operating cost estimates ranged from $0.50 per ton to $1.35 per ton. However, the work does not report existing operating or capital costs, and these additional costs cannot be fully placed in context. However, there are other examples of implementation at plant scale of this approach, albeit at operating sites rather than in the context of reworking older wastes. The Magma Copper Company has produced pyrite products at its Superior Mine operation by passing tailings from the copper circuit through an additional flotation circuit, thereby generating a less reactive tailings product, plus a fine, virtually pure pyrite product and a coarse pyrite concentrate (45-47 per cent iron, 48-50 per cent sulphur) (USEPA, 1994a). Approximately 500 tons per month of pyrite products were sold in 1994, representing 90-95 per cent of the United States market (USEPA, 1994b). However, in this case saleable pyrite products were generated because the ore (a) contained up to 25 per cent pyrite and (b) had few impurities. Those factors may make the deposit relatively unique, and thus the transfer of this approach to other operations may be more difficult than it might first appear. As noted above, the driver behind pyrite production was not strictly environmental (although the company did recognize the benefits accruing from reduced acid rock drainage generation) but rather demand for the product – when there was no demand, there was no recovery of pyrite. This emphasizes the difficulty of dealing with minerals, such as pyrite, which have little or no market niche or value.

B. Reprocessing via bioleaching

39. Bacterially mediated leaching has been used to process refractory gold, hitherto unrecoverable due to its crystalline association with pyrite, which the bacteria can readily dissolve. Advances in biotechnology, combined with the environmental and economic advantages that bacterial leaching technologies appear to have over other larger-scale, more capital-intensive and more polluting traditional processes, may herald substantial changes in the structure of the minerals industry. In March 1994, Newmont Gold reported that field tests had confirmed the economic viability of a patented bioleaching process to recover gold from low-grade sulphide material that would not previously have been considered to be economic ore (Brewis, 1995). The system uses *Thiobacillus ferrooxidans* and *Leptospirillium ferrooxidans* to oxidize the gold-bearing sulphides on a heap leach pad, and then cyanide or ammonium thiosulphate leaching to remove the gold. Although the reaction kinetics are slow, this approach is economically viable due to the low cost of the biological systems used. To date, bioleaching has only been applied commercially to the recovery of gold, uranium, copper and nickel; its use has also been suggested for heap leaching of low-grade zinc ores.

C. Alternatives to cyanide in gold recovery

40. Although cyanidation is the major route used for gold recovery at formal operations (100 per cent of formal gold production in South Africa) (Adams, 1997), cyanide is not the only lixiviant with the potential for use in gold recovery. Other potential alternatives to cyanide include thiocyanate (Adams, 1996) and halogen-based solvents, such as chlorine gas, sodium hypochlorite, iodine and bromine (Ramadorai, 1994). None of these could be considered a generic replacement for cyanide, but they may be useful in the treatment of specific ore types or gold-bearing wastes for which no economically or technically viable processing option exists at the time of disposal. Indications are that for non-refractory ores, halogen solvents are no more efficient

or cost-effective than cyanide. Instead, halogen solvents may find more greater application in the treatment of refractory ores and wastes, although this remains an area requiring further substantiation.

X. Utilization, reprocessing and source reduction approaches

A. Source reduction in mining, mineral processing and extractive metallurgy

41. Clean technology is an integral component of – and is often considered synonymous with – waste minimization and pollution prevention (source reduction), and has principally been used and indeed developed within the process industries. Ideally, in assessing the "cleanliness" of a technology, the environmental performance of upstream suppliers and downstream users and disposers of products should also be taken into account, although this is often difficult to determine and the boundaries of such evaluation are in practice restricted more closely to the process in question.

42. A number of generic or cross-sectoral strategies are adopted within an overarching management system to facilitate pollution prevention: (a) improved plant operations, (b) alterations to process technology, (c) recycling, recovery and reuse of waste products, (d) changing raw materials and (e) product reformulation.

43. In the context of base and precious metal mining and processing, strategies (a), (b) and (c) above have the most obvious applications, although the capacity does exist occasionally to change the nature of the process input (i.e., strategy (d)), for example by selective and more accurate ("right-in-space") mining practices (Almgren et al., 1996). Strategy (e) is of little direct relevance to the mining industry and is ignored here.

44. Where there are a number of competing clean technologies, they can be ranked according to the reduction in the hazards associated with their waste outputs, treatment/disposal costs, future liability, safety hazards and input material costs. The means of determining the cleanliness of a particular technology relies heavily on the assessment of resource usage and environmental impact using life cycle inventory and life cycle assessment (LCA) methodologies.

45. Although the benefits of waste minimization are wide-ranging, there are often institutional disincentives that may need to be overcome, such as management uncertainty due to unsure investment returns, the potential for production downtime, problems with product quality and loss of proprietary information to waste reduction consultants. The best way to circumvent those obstacles is to involve top and middle management, plant management and plant operators (i.e., the complete corporate structure) (Haas, 1995).

B. From waste management to waste prevention and back again

46. The current trend in the mining sector towards source reduction is being undermined by such issues as those surrounding low-value but environmentally harmful minerals present in base and precious metal ore bodies, for example arsenic and pyrite. Arsenic is a particularly topical example of the problems and issues associated with the sub-economic and toxic contaminants commonly associated with valuable mineral assemblages. It is mainly produced as a by-product during the production of other more important metals, such as copper, lead, zinc, gold, silver and tin. Commercial grade arsenic trioxide is recovered from the smelting or roasting of non-ferrous metal ores or concentrates in at least 18 countries (Broad, 1997). Future market opportunities do not look promising for arsenic, with lead-arsenic alloys in batteries being replaced with lead-calcium equivalents and increasing pressure on low-tech uses, such as timber treatment.

47. Many of the treatment technologies that have been developed for the safe disposal of hazardous wastes do not apply to arsenic-contaminated mineral wastes. To compensate, other possible routes are under development, involving:

(a) "*Synthetic mineral immobilization technology* (SMITE)": SMITE treatment precipitates or converts metals into non-volatile forms and then adds appropriate "tailoring" chemicals so that during the conversion phase the desired synthetic mineral assemblage is formed (White and Toor, 1996). SMITE has been used for the stabilization of arsenic flue dust (containing arsenic trioxide) in the form of a low solubility apatite-type mineral ($Ca_5(AsO_4)_3F$);

(b) "*Ferric arsenates*": research on the high temperature precipitation of dissolved arsenic as stable, crystalline ferric arsenates has been under way for a number of years (see, for example, Swash and Monhemius, 1994, and references therein). Ferric arsenates are generated by the dissolution of the arsenic species (commonly arsenic trioxide (Van Weert and Droppert, 1994)), followed by conversion

to crystalline scorodite ($FeAsO_4.2H_2O$) using iron-bearing acidic nitrate (or sulphate) solutions at temperatures ranging from 140°C to 160°C;

(c) *"Incorporation in silicate slags"*: alternatives to the formation of low-solubility mineral phases include the incorporation of arsenic in silicate slags. Research has indicated that up to 10 per cent arsenic by weight can be incorporated into "glassy" silicate slags, with very low arsenic release during subsequent leaching (Machingawuta and Broadbent, 1994).

48. Despite these recent advances, the issue of arsenic recovery, treatment and disposal is one that has still to be resolved. The lack of markets for arsenic by-products removes the financial incentive for recovery (although recovery is often achieved incidentally during the processing operation), and the financial implications of liability are not sufficiently developed to act as an alternative driver. Where there is no market for a particular waste or by-product and the presence of the contaminant in the process feed is unavoidable, the development of a truly "clean" technological solution is impossible. The alternatives are to (a) not exploit ores containing problem metals and minerals for which there is no market, or (b) accept that the recovery, isolation and effective treatment of the problematic elements prior to disposal is the optimal option. Realistically, it is the latter case that will predominate, although there have been instances of proposed mining developments being rejected on the basis of generally unacceptable risk (New World Mine on the edge of Yellowstone National Park, United States), which may set a future precedent for restrictions on mining on or near "sensitive" sites not already "protected" from such activity. At the very least, the unpalatable nature of restrictions on mining may help to promote the recovery and predisposal treatment of non-target and non-economic metals and metalloids if that can be established as the best environmental option based on rigorous scientific studies.

XI. Conclusions: optimizing source reduction, reprocessing and utilization

49. State-of-the-art technologies are difficult to describe in absolute terms since the supporting tools with which assessments are made, such as LCA, have not yet been fully developed. Neither are the ecotoxicological implications of utilization and reprocessing fully understood, although advances in site-specific ecotoxicological assessments have reduced uncertainty associated with some remedial actions at mining sites (Pascoe, 1994; Greene and Barich, 1994). There is, however, an increasing pressure on those involved with waste management to develop a sustainable approach and to integrate relevant strategies to engender the best practicable option for environmental protection (Barton et al., 1996). Realistically, there will always be a requirement for the parallel use of source reduction, reprocessing, utilization, treatment and low-tech remedial solutions in the mining sector. Each has a niche, and although the balance can be expected to change with time, none will be subsumed completely. Many potential agencies – government and private – that could potentially be involved in the remediation of mine sites (and by extension, reprocessing) are impeded by regulatory and institutional barriers, such as the question of liability. These not only impede the physical reclamation or remediation of sites but also tend to stifle capital investment in the development of innovative technologies (Durkin, 1995). The question, therefore, is how regulation can be used to promote the reprocessing and utilization of mining industry wastes more effectively than currently implemented approaches.

50. The remediation of existing mine sites represents a significant opportunity to develop new and innovative technologies for the reprocessing of mine wastes, and to develop policy and technical procedures to promote the utilization of secondary wastes rather than primary resources, where possible. Increasing constraints on the exploitation of primary resources have elevated wastes into potential resources themselves. Regulatory standards and quality standards may impede the use of innovative technologies, and there may also be technical barriers to the reprocessing of certain complex waste materials. Innovative technologies may also have limited cost and performance information, which in turn generates a lack of incentive to invest in innovative technologies. State-of-the-art technologies must also compete against a growing number of stabilization techniques (SMITE). While such technologies have disadvantages, such as lack of credibility and concerns about their long-term stability, they may, however, be the only practicable solution for minerals/metals with little or no market value.

Notes

[1] Below this size, particles become increasingly difficult to handle and/or separate.

[2] There has been a substitution of elemental sulphur for pyrite in the production of sulphuric acid (Berkowitz, 1988), indicating that the sale of pyrite might not be commercially viable.

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Issues related to the social and economic impacts of the mining sector, especially in developing countries and economies in transition

Basic problem of improving the capacity of developing countries and economies in transition to capture the maximum economic and social benefits of their potential for mineral production

Report of the Secretary-General

Summary

The present report, which has been prepared in response to Economic and Social Council decision 1996/306, considers effective mechanisms for improving the capacity of developing countries and countries with economies in transition to maximize the economic and social benefits of mineral production.

In those countries making the transition from central planning to the free market and in most of the developing world, minerals production is currently undergoing a transformation. Over the past decade, many developing countries and countries with economies in transition have liberalized their investment regimes for mining and have privatized formerly state-owned mineral assets. The restructuring of fiscal and regulatory regimes to encourage foreign investment and the associated influx of mining capital, technology and skills are transforming traditional relationships between mining firms, local communities and the Government in many developing countries. That transformation has necessitated a re-evaluation of the most effective policy approaches to capture increased economic and social benefits of mineral production.

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The present report considers effective mechanisms for improving the capacity of developing and transition countries to maximize the economic and social benefits of mineral production. Mineral economies – defined as those generating at least 10 per cent of gross domestic product from mining and at least 40 per cent of their foreign exchange earnings from mineral exports – account for over one quarter of all developing countries and countries with economies in transition. In many additional countries, mineral production also occupies a central role in public policies to promote local, regional and national economic development.

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I. Assessing the feasibility of increasing economic and social benefits in mineral economies

1. Future economic and social development in the mineral economies of developing countries and countries with economies in transition will be closely linked to the ability to develop innovative mechanisms to capture, retain, and use the fullest range of benefits from mineral production. Mechanisms for the effective capture and allocation of mineral revenue streams will remain central to the development objectives of developing and transition economies. There is a need, however, to be creative in the design and implementation of those mechanisms to facilitate investment, create new economic opportunities from mineral development, and derive lasting benefits that extend beyond the revenue stream alone. Thus, in addition to revenue generation, new mineral-related investments provide an opportunity for harnessing the technological, managerial and institutional capabilities of inwardly investing firms to build local capacity.

2. Developing and transition economies face many similar challenges in improving their capacity to maximize the economic and social benefits of mineral production, such as the needs to diversify linkages between mineral production and local economies, to develop mechanisms for a more equitable allocation of mineral revenue between national, regional and local governments, to increase public participation in decisions over mineral resource development, and to work within the constraints of limited public resources for social investment. There are, however, several significant differences between countries with economies in transition and developing countries that will affect the feasibility of implementing specific policy approaches to build capacity. These differences include the infrastructure, staffing and technical knowledge of state agencies, different priorities for social investment projects, the relative size of income inequalities within the general population, popular attitudes and receptivity to foreign investment, and the rate, extent and success of liberalization policies.

A. Mineral resources and development

3. The natural resource sector – particularly minerals production – has traditionally been identified by public policy as an "engine of growth" for the development of local, regional and national economies. That popular view rests on a model of the natural resource base – the export base model[1] – which asserts that economies with rich resource endowments can create economic stability and growth by meeting an external demand for their primary products through export. By providing raw material exports to the wider economy, actively developing increased economies and scale, and promoting strong regional linkages, investment in the natural resources sector will initiate a process of cumulative causation leading to economic growth, stability and diversification. That resource-based strategy of industrialization will then create a "spread effect" as a result of developing appropriate linkages between the natural resource sector and the local economy. The range of potential linkages includes:

(a) Backward linkages to those supplying capital inputs for the sector;

(b) Forward linkages to those buying output from the sector;

(c) Final demand linkages to firms supplying consumption goods to workers in the natural resource sector;

(d) Fiscal linkages through taxation, royalties and resource rents.[2]

4. For many natural resource economies, however, the process of economic diversification and sustainable growth based on natural resource exports has been elusive. In many instances, the development of the natural resource base may fail to provide the conditions necessary for anticipated economic stability, diversification or increased social opportunity.[3] Thus, many mineral economies can be characterized by:

(a) Cyclical expansions and contraction of activity (boom and bust cycles);

(b) Limited employment opportunities outside of the minerals sector;[4]

(c) Dependent or "enclave" patterns of development;[5]

(d) Highly skewed income distribution;

(e) Inadequate financial planning for asset replacement;

(f) Low revenue retention;

(g) Under-investment in institutional and social capacity.

5. Contrary to the expectations raised by the export-base model, therefore, a consistent underperformance of mineral economies relative to non-mineral economies has been observed. The extent of that underperformance has been

significant enough to lead some commentators to suggest that resource endowment is more of a curse than a blessing (Gelb, 1988; Nankani, 1979; Auty, 1993). Effective policy approaches to maximize economic and social benefits from minerals production will need, therefore, to consider carefully the causes of such underperformance and develop mechanisms that are able to both capture benefits and minimize the costs of dependence on natural resources.

B. Challenges and opportunities of mineral economies

6. The principal obstacle to sustained economic growth and stability in economies based on the extraction of non-renewable resources is not depletion of the natural asset but the volatility of the revenue stream derived from mineral resource development.[6] The characteristic volatility of mineral sector revenues can create a series of negative spillover effects for local, regional and national economies based on mineral development,[7] such as the uncertainty of projecting future mineral revenues, a decline in the competitiveness of non-mining tradeable goods (known as "Dutch disease"[8]), and a cyclical process of windfalls and shortfalls in government revenues that require prudent management if they are not to amplify the tendency to boom and bust (Auty, 1993).

7. The management of the way in which resource revenues captured by the Government are deployed can be particularly significant for the development of sustained economic growth and the maximization of social benefits. Resource revenues are often deposited directly into the State's general fund so that resource revenues become just one of several revenue streams for allocation by the State to various economic and social activities. That can be problematic since unlike many other revenue streams, revenues from non-renewable resources are non-recurring, and often encourage dependence, cause inflation and distort the economy (Poole et al., 1992). The economic distortions caused by the influx of mineral revenues require the State to allocate scarce resources to remedy the damage to the non-mining sector. That process of crisis management reduces the economic efficiency of the mineral sector and precludes investment in capacity-building. Analysis has shown the economic distortions from mineral revenues to be the key impediment to sustainable development in hard mineral economies (Auty, 1993).

8. The tendency towards economic distortion is exacerbated by the fact that modern mining operations – such as those currently being developed as part of the restructuring of the minerals industry in developing and transition economies – tend to have high capital-to-labour ratios, modest local production linkages and large overseas capital flows. As a result, the strongest linkage between the mining sector and the local and national economy often tends to be fiscal, as opposed to the backward, forward or final demand linkages identified for other economic sectors (see para. 3 above). Since it is those fiscal linkages that are paramount, a central public policy objective is the design of institutions (such as stabilization funds) and mechanisms (taxation policy, regulations concerning trust fund management) that buffer the short-term distortions of mineral price volatility and maximize the long-term gains from mineral revenues (Lewis, 1982; Auty, 1993).

9. The development of mechanisms to contain the economic distortions caused by mineral revenues needs to be a primary objective of efforts to increase the capacity of developing and transition economies to maximize the developmental benefits of mineral production. In addition to the socio-economic challenges outlined above, mechanisms for managing the sociocultural impacts of mining, creating positive opportunities for training, skill acquisition and social investment, and broadening and diversifying public participation in decision-making at major mineral projects are likely to become increasingly significant as mining activity expands into frontier areas in developing and transition economies.

II. Improving capacity to capture increased economic benefits from mineral production

10. In response to the fiscal crisis of the State, and propelled by the conditions attached to international development loans and the requirements of structural adjustment programmes, many countries have passed legislation over the last 10 to 15 years to encourage foreign investment in the minerals sector.[9] Declining mineral prices in the early 1980s and stagnant demand made it increasingly difficult for government-owned mining companies to finance the management and technical changes necessary to reduce costs and remain competitive. The attraction of international mining capital and the promotion of domestic market-led enterprises through the creation of a legal regime that provides certainty to investors has been identified by many countries as a means of overcoming those financial constraints. Although many areas of the developing world were not formerly closed *de jure* to foreign investment, the political and economic risks associated with investment in

these areas were often judged sufficiently high to deter prudent investment. Concern over political unrest, the possibility of expropriation or sudden changes in taxation policies or the laws on the repatriation of profits, for example, precluded large-scale foreign investment (Warhurst and Bridge, 1997).

11. Over the last 10 to 15 years, many countries have begun to pass legislation designed to improve the investment climate, in particular to encourage foreign interest in mineral resources. Since 1989, for example, over 75 countries have liberalized their investment regimes for mining (MERN, 1996a). The specific manner in which that process of liberalization has been undertaken varies considerably from country to country, but virtually all cases demonstrate a measured retreat from former policies of government intervention in minerals production. For example, the composition of investments entering the mining industry in Bolivia has shifted strongly from the public sector to the private sector since 1985. That trend reflects the combined effects of reduced state resources available for investment in mining activities and a sustained policy of promoting private sources of investment in productive industry in lieu of state sources. That policy is most clearly reflected in the decision of the Government of Bolivia to exit the mining and metals sector through the capitalization of the Vinto smelter and the transfer of operating control over the mining assets of the Corporación Minera de Bolivia to the private sector.[10]

A. Policy objectives

12. The liberalization and privatization of the natural resource sector in developing countries and economies in transition reflects a fundamental reappraisal of the State's role in the development of natural resources, and is often associated with a shift from an import substitution model of development to one based on the promotion of exports.[11] Rather than being the owner, operator and regulator of mineral production, the State's direct role has been reduced and transformed to that of a facilitator of private mineral production. Although in most cases mineral resources remain state property, the development of those resources into productive assets is increasingly undertaken by the private sector. The State aims to ensure social benefits from mineral extraction not through controlling the means of production but through the mechanisms of regulation and taxation. A central objective of policy intervention to build capacity in mineral economies is to encourage new mineral investment and establish institutional mechanisms to capture benefits and minimize the costs of dependence on natural resources. Those institutions convert the revenue from non-renewable resource extraction into a renewable resource – capital – that can be allocated to achieve growth and development objectives.

B. Fiscal linkages

13. Tax revenues are one of the principal mechanisms by which countries capture economic benefits from mineral production. Governments have a variety of taxation policies at their disposal, ranging from the normal channels of corporate and income taxation through to royalties on specific minerals. Foreign direct investment in the mineral sector is sensitive to the extent and flexibility of the taxation regime in developing and transition economies. Accordingly, structuring a taxation regime that is sufficiently flexible to attract foreign investment yet robust enough to ensure increased resource revenues to the State remains a major challenge for developing economies.

14. The package of neo-liberal reforms adopted in developing and transition economies represents policy approaches to increase tax revenue from mining and mineral processing, both from mineral taxation directly and from a higher level of economic activity as a result of mineral development. The objective has been to set tax rates at a level that encourages investment so that mineral revenues to the Government rise as a result of increased investment and mining activity.[12] New mining legislation enacted in Greenland, for example, avoids royalties entirely and reduces government intervention for revenue collection in the minerals sector to corporate taxation alone (Poole et al., 1992). Although it reduces potential returns to the State in the short term, that policy may increase the attraction of foreign capital to investing in Greenland's natural resources in the longer term by decreasing the investment risk. Peru has similarly restructured its tax code with the objective of increasing revenues from mineral production by accelerating foreign investment in the mineral sector.

15. Like Peru, the restructuring of regulatory frameworks in other developing and transition economies is indicative of the competition between liberalizing countries for foreign mining capital, as each country seeks to create a competitive fiscal regime, attractive investment policies, and transparent and expeditious permit processing (Andrews, 1992). Although it is generally welcomed by the minerals industry, senior mining analysts have begun to question whether competitive bidding between countries for a fixed amount of investible funds has driven tax rates below the levels required for the long-run sustainability of mining in

individual countries. It is worth noting that Papua New Guinea's Minister for Mining and Petroleum recently announced new policy initiatives that *increased* royalty payments to landowners in an effort to restore harmonious relationships between landowners and mineral producers and create the social and political conditions conducive to long-term investment (Mining Journal, 1996a and 1997).

C. Fiscal incentives to facilitate development of local capacity and corporate best practice

16. It is clear that many developing countries are structuring their tax code to encourage foreign investment in the mineral sector. It is less clear, however, whether the full potential of tax incentives in encouraging corporate strategies to achieve best-practice performance has been realized. For example, enabling firms to make their expenditures on the innovation and application of cleaner production technologies tax deductible could accelerate the adoption of cleaner processes as part of foreign direct investment. Similarly, allowing firms to make tax deductions for funds set aside for closure and site reclamation could facilitate proactive clean-up at mine sites, while tax benefits could be provided for investment in secondary (i.e., downstream) processing of mineral concentrates. For example, since 1990 Greenland has allowed taxable income to be reduced by 10 per cent annually of investment in secondary processing (Poole et al., 1992). There is also considerable scope for innovative tax policy that would allow companies to make social expenditures in the vicinity of the mine in lieu of taxes (Cooney, 1995).

D. Management of mineral revenues

17. The large size, non-recurring and highly volatile nature of revenues from mineral production highlights the need for prudent policies and robust mechanisms to invest and allocate windfall rents in projects sufficient to replace depleted ore assets. The experience of several countries has shown that the allocation of windfall rents is often subject to domestic political pressure and could be much more prudently managed. There is a tendency to use windfalls to boost consumption (by reducing taxation) rather than investing in production or social welfare. The increased revenue experienced by Bolivia from the oil price rises in 1973-1974 and 1979, for example, were used to lower taxes and had the effect of increasing foreign debt to the point at which foreign loans were halted in 1980 (Auty, 1993).

18. Venezuela and Saudi Arabia have used resource revenues to develop economic infrastructure in an attempt to diversify the national economy and reduce dependence on natural resources. Although their short-term goals – such as employment generation in infrastructure development – have been successfully met, the long-term success of such state-sponsored policies of diversification must be judged against the continued significance of natural resources exports to the economies of those countries. In contrast to Bolivia's consumption boom and the infrastructure investments of Venezuela and Saudi Arabia, Chile has adopted policy approaches to dealing with windfalls that illustrate a process of learning from the experience of other mineral economies. At the urging of the International Monetary Fund, Chile established a mineral stabilization fund in 1985 to secure mineral benefits while protecting the rest of the economy from either rapid injection or withdrawal of mineral revenues, and successfully used that fund to retire debt (Auty, 1993; Poole et al., 1992).

E. Mineral stabilization funds

19. Mineral stabilization funds segregate mineral revenues from other sources of government revenue and serve as an internal buffer to reduce the impact of revenue fluctuations in that volatile sector on public spending and exchange rates. The fund accumulates reserves in years when market prices exceed an anticipated reference price. In the case of Chile, the price differential between reference and market prices is split into three stages, requiring a progressively greater percentage of the differential be paid into the fund. Its success is linked to a sound mineral taxation policy, structured so as to be able to extract windfall revenues without deterring long-term investment in the mineral sector. The copper fund accounted for one quarter of Chile's official reserves of $2 billion in 1988, and by 1989 the fund had increased to $1.7 billion (Auty, 1993).

20. Permanent trust funds represent an approach to harnessing the high-volume short-term revenues from non-renewable resource extraction to lower debts and taxes, improving social services and creating short-term business opportunities outside of the mineral sector. Permanent trusts with principal derived from natural resource revenues have been adopted by federal and state governments in developing and developed economies, and typically receive between 1 and 30 per cent of revenues derived from non-renewable resource development. The state of Alberta in Canada, for example, has a development fund that invests resource revenues as loans to other provinces, as equity in

development projects, or in projects to build local capacity, such as irrigation, recreation and health-care facilities or scholarship funds (Pretes and Robinson, 1989). Permanent trust funds are distinct from state-managed accounts, and typically incorporate the following features (Poole et al., 1992):

(a) The fund principal is protected from expenditure by the Government;

(b) The capital source is distinct, i.e., does not derive from general fund transfers;

(c) The principal is held in trust for beneficiaries, with the State acting as trustee;

(d) The fund is designated with a special purpose or serves some function other than general state expenditures;

(e) Income derived from fund investments may also have a special purpose.

21. Capital in the trust fund increases through deposits and investment income, so that the original capital is preserved and earnings can be used to finance the state's budget or development initiatives. Thus, the trust fund converts the non-recurring income from non-renewable resource extraction into a renewable resource, and fund earnings can replace the income stream from the natural resource once the resource is depleted (Poole et al., 1992).

22. Papua New Guinea, which has witnessed increased investment and production in copper and gold projects over the last decade,[13] has accumulated experience in the successful application of mineral stabilization funds. The country first used stabilization funds to mitigate the impact of revenue fluctuations on the economy from the world-class Panguna copper mine at Bougainville. In the early 1970s, revenues from the Bougainville copper mine were placed in the fund, and since copper prices and revenues fell during the mid 1970s the fund played a significant role in public spending. The country also used the fund to successfully offset the economic disruption when Bougainville suddenly closed in 1989 following its takeover by secessionist forces. Bougainville had provided one third of Papua New Guinea's gross national product, and the fund was used to cover for the sudden loss in revenue and provided a means for the Government to avoid sharp revenue fluctuations while negotiating external loans. Deployment of income and principal from the fund was able to cover the period from the cessation of production at Bougainville in 1989 to 1992, when expansion at other mines (Ok Tedi and Misima) would provide revenue flow (Auty, 1993).

23. In summary, permanent trust funds can serve several functions in increasing the capacity of countries to maximize economic benefits from minerals development (Poole et al., 1992), by:

(a) Saving resource revenues that would otherwise be consumed;

(b) Extending the benefits of resource revenues over several generations or in perpetuity;

(c) Providing an additional source of budgetary income;

(d) Being used to intervene in the economy to achieve state objectives, such as diversification or stabilization;

(e) Providing an additional or alternative source of investment capital;

(f) Externalizing windfall effects and preventing distortions from arising in the economy.

F. Institutional measures for isolating mineral revenue

24. In addition to the creation of trust funds that isolate mineral revenues from other forms of state revenue and expenditure, there are several other institutional measures designed to separate mineral wealth from the political process that have proved successful in dampening the destabilizing effect of revenue booms. Chile, for example, increased the autonomy of the Central Bank in an effort to reduce political control over money supply and foreign debt. Other countries have sought to provide constitutional protection to mineral revenues. Poole and others (1992), for example, illustrate the significance of constitutional protection to the success of Alaska's Permanent Fund, which was established in 1976, receives 25 per cent of most non-renewable resource revenues, and is valued at over $12 billion. Although the legislature has discretion over investment income, Alaska requires a state referendum to amend the state's constitution before Permanent Fund monies can be spent. That isolation of mineral revenues from the political process is regarded as highly significant in preventing fund misappropriation by government or interest groups.

G. Leases and performance bonding

25. Since the successful development of mineral deposits typically requires large amounts of capital, skill and expertise, the development of mineral resources –

particularly where the mineral estate is owned by the Government – is often conducted through leasing. The lease is a legal instrument that conveys the right to develop a deposit to another party, and binds the lessee and lessor into sharing the benefits from the development. If used effectively, the lease can be a significant mechanism for creatively harnessing the economic and social benefits of mineral production and for building technical and managerial capacity.

26. The lease provides a series of rights to the lessor that can be used to capture economic and social benefits from the mineral resource. Under most leases, the costs of exploration, development and production are borne by the lessee, while the benefits reserved for the lessor are negotiated between the parties. Analysis of the operation of mineral leases for oil and gas in the United States of America has illustrated that there are three central elements within the lease that facilitate the lessor in capturing a diverse range of economic and social benefits:[14]

(a) The right to bonus – the sum paid to the owner of the mineral deposit by the developer in order to acquire the lease. Proven deposits will command a higher bonus than unproven deposits;

(b) The right to delay rentals – the sum paid to the owner of the mineral deposit by the developer if the developer decides to delay the commencement of operations. Where no production is obtained, delay rentals can be the most valuable right to the owner of the mineral deposit;

(c) The right to royalty – a fractional part of the minerals paid to the owner of the mineral deposit as share of the profits from the mineral development. It can be considered the owner's share in the profits of a joint enterprise in which the owner puts up the land and the recipient of the lease puts up the capital and skill.

27. The leasing process therefore provides an opportunity for the mineral owner to establish appropriate mechanisms for capturing the economic and social benefits from specific mineral projects. The lease agreement between the resource developer and the Northwest Alaska Native Association (NANA) at the Red Dog zinc mine in Alaska, for example, provided NANA a bonus of $1.5 million on signing, $1.0 million delay rentals every year until production began, and an annual royalty of 4.5 per cent of net smelter return, rising to 50 per cent over 25 years once the developer has recovered capital costs. In countries with experience of mineral leasing, such as the United States, Canada and Australia, there is a tendency for leases to be "front-loaded" with terms and conditions since the opportunity for intervention is more limited in the post-lease stages.[15] Since there is no way of knowing at the time of the lease issuance whether the lease will proceed through all stages of production and to closure, there is also a need to retain a review stage in which lease terms and conditions can be adjusted and renegotiated during project development.

28. Performance guarantees can be established to provide incentives for continued investment in local infrastructure and programmes to build social capacity over the life of the mine. Such performance guarantees are financially supported through the use of performance bonds, which can be structured either as a mine-specific bond or as a fund that can be used for wider social issues, many of which may only be indirectly related to mining. Several countries currently use bonding as a principal tool to ensure surface reclamation and restoration, and that mechanism could be adapted to cover social as well as environmental impacts. Like environmental bonds, social performance bonds can – if appropriately structured and administered – strengthen the capacity of existing institutions to facilitate foreign and domestic firms in achieving and maintaining environmental and social best practice at mining operations, from exploration through development and production to closure.

III. Improving capacity to capture increased social benefits from mineral production

29. The restructuring of investment regimes for mining is indicative of a shift in thinking about the most effective way for Governments of developing countries and transition economies to promote the strengthening of social, technical and managerial capacities. That shift can be characterized as a transition from state-centred strategies of intervention towards the facilitation of private enterprise and market mechanisms to deliver capital, technology and skills, and to build social, technical and institutional capacity. There is now widespread recognition that foreign direct investment deserves particular attention as a potential channel for the development of technical and managerial capacity, the diffusion of best-practice approaches, and the leveraging of social investment. Not only has foreign direct investment in prominent sectors, such as mining, increased dramatically in the last 10 years,[16] but competition between countries for inward investment has led to a decline in the relative capacity of Governments to mandate contractual terms and conditions for the provision of social benefits from minerals production. Thus, innovative approaches towards improving the capacity of developing and transition economies to maximize the social benefits of mineral production involve

the creation of new partnerships between industry, local people, government, and multilateral development agencies.

A. Increasing social opportunity through diversification

30. Diversification has been promoted by many local and regional governments as a means of reducing the exposure of mineral economies to cyclical downturns in mineral prices. The objective is to increase the capacity of the mineral economy to ride out price fluctuations by dispersing economic activity across several different sectors and avoiding concentration in a single, highly volatile sector. Policies of economic diversification can either be vertical (promoting downstream parts of the core business to capture value-added activities, such as processing and fabrication) or lateral (promoting activities that are more autonomous from those of the core sector). Although widely adopted, policies of economic diversification have often met with only limited success.

31. An innovative and successful partnership to maximize social benefits can been seen in the development by Cominco of the Red Dog Mine on territory owned by the Northwest Alaska Native Association (NANA) in Alaska, United States. The world class Red Dog zinc deposit, which began producing high-grade zinc, lead and silver in 1989, is considered a model of progressive northern development, and provides an insight into how the development of large mineral projects in transition and developing economies might be harnessed to build local capacity. The NANA/Cominco development agreement sought to extend conventional efforts at economic diversification through a comprehensive programme to develop local capacity and provide a sustainable economic base for the region. Specifically, the agreement gives Cominco the right to build and operate the mine and market the metals. In return, NANA receives an escalating percentage of royalties that will eventually reach 50 per cent of mineral profits. The agreement also provides local people with employment flexibility, allowing indigenous people to pursue a traditional lifestyle while providing modern training and employment. A subsistence advisory committee establishes strict protections to ensure that development does not interfere with subsistence activities such as hunting and fishing, while a shareholder hire programme establishes hiring preferences for indigenous NANA shareholders to work at operations. A joint NANA/Cominco management committee has been established to review and approve operations activities, an employment committee has been set up to assist in hiring, training and promoting NANA shareholders, and NANA and its subsidiaries provide drilling, catering and other contracted services to the project.

B. Alternatives to diversification

32. The development of capacity through economic diversification may not be an appropriate or feasible policy approach for maximizing social or economic benefits at all mineral operations. Some mineral economies, for example, have sought to manage the social and economic costs of mineral development by encouraging innovative, alternate approaches to the development of the extensive economic and social infrastructure often associated with mineral development. One approach is to reduce traditional backward and forward linkages to the local economy to a minimum by not promoting economic growth and its attendant service and administrative infrastructure at the site of production. Rather, resource rents are captured through fiscal means and are allocated for economic and social development projects in the wider regional economy. That may be particularly appropriate for frontier areas with low population densities, where a workforce can be more cost-effectively recruited from distant locations on a fly-in basis rather than being sustained on-site. Such a strategy was originally pioneered for resource development in locations where the costs of habitation are restrictive (for example, offshore oil) but has since been applied with success to mining operations, such as those in Western Australia (Houghton, 1993).

C. Participatory approaches to social investment

33. There is considerable scope for the development of participatory approaches between government, local community, industry and other interested parties to maximize economic and social benefits from mineral projects and achieve broader development objectives. The integration of mining projects in developing and transition economies into broader regional development programmes, supported by developmental aid agencies, multilateral financial agencies and/or non-governmental organizations, increases the opportunities for building local capacity during the development and operation of a mineral project. A number of mining companies active in developing and transition economies have already demonstrated their support for partnerships, noting that in addition to their developmental benefits, partnerships provide added security

of investment in the short-term and can facilitate the emergence of favourable conditions for investment over the longer term (Cooney, 1995).

34. For example, Placer Dome has actively implemented a partnership model of social investment at its Las Cristinas Project in Venezuela.[17] Company strategy has sought to strengthen existing efforts within indigenous communities to promote the expansion and diversification of the non-traditional cash economy with the objective of increasing autonomy and providing the resources to secure traditional activities and social institutions. Indigenous communities have, for example, secured carpentry and forest products supply contracts with the mining company. The company has also countenanced small-scale artisanal mining activity on parts of the Las Cristinas property, and initiated a social investment programme during the final phase of exploration, which provided assistance to expand a local school, improve a local clinic and install a new water storage tank. That initial programme is to be supplemented with increased capacity-building activities that aim to strengthen community capabilities and institutions. Specifically, over the life of the mine, the programme aims to (Cooney, 1996):

(a) Improve the level and distribution of income within local communities;

(b) Facilitate the creation of a sustainable, diversified economy;

(c) Encourage local initiatives and the development of stable communities;

(d) Increase the level of education and training within communities;

(e) Improve the quality of life and access to essential public goods and services;

(f) Minimize environmental impacts;

(g) Increase the participation of women in development.

35. A key component to that partnership model of social investment is the establishment of dialogue and consultation between different stakeholder groups affected by mineral development. Increased public participation in decision-making at all stages of minerals development, from initial exploration through development and operation to closure and the establishment of post-mining land use, represents a significant contribution to the development of a country's capacity to maximize the benefits – and minimize the costs – of mineral production (MERN, 1996b).

36. In the case of Las Cristinas, for example, the company entered into an agreement with the Canadian International Development Agency in 1996 to complete a viability study for a local economic diversification initiatives (social economic improvement) programme. The objective of that agreement was to create a strategic framework for promoting long-term social, economic and environmental sustainability of local communities through the activities of local non-governmental organizations and international non-governmental organizations and with the support of the company. Projects for consideration during the development of the strategic framework included investment in eco-tourism, upgrading of aviculture facilities, technical assistance for small-scale mining, sewing workshops, cement block fabrication, and the development of local organization and leadership capacity, education and training, and micro-enterprise financing.

D. Indigenous rights and revenue-sharing

37. The allocation of rights to revenues, employment and other benefits from mineral investment can be a key consideration in promoting the development of local capacity (see, for example, the case study of recent initiatives in South Africa contained in the present report). Mineral rights in many countries are typically held by the national Government, with rights to extract the mineral transferred from the Government to a private company through a lease or concession agreement.[18] A principal consideration for policy approaches to develop local capacity is the design of revenue-sharing agreements between national, local and regional governments to facilitate the return of a significant proportion of the mineral revenue stream to subnational (local and regional/provincial) governments and communities. The Philippines, for example, has a national wealth revenue sharing programme, in which 40 per cent of revenues are returned to the mining region by the central Government. Peru has a similar programme, in which one fifth of the income taxes from mining activities are distributed to regional governments (20 per cent) and local governments (80 per cent).

38. The often limited institutional capacity of developing countries has raised concerns that the traditional model of mineral revenue distribution, in which the central Government receives revenues from mines via taxes and then distributes benefits to the population in the vicinity of the mine, does not work effectively in many developing and transition economies. There is potential, therefore, for increasing capacity through the development of an innovative tax policy that either channels taxes more effectively to local communities or allows companies to

make social expenditures in lieu of taxes. Such policies could be not only more effective in delivering social programmes tailored to the needs of the communities directly impacted by mining development but also more economically efficient. Policies that provide tax relief for companies making social expenditures could provide a creative response to the particular challenges of mineral developments in frontier areas, where foreign companies may play the role of surrogate government, providing goods and services to communities for which the Government has the responsibility but not the capacity to deliver (Cooney, 1996).

Case study. Public policy approaches to capturing economic and social benefits of minerals development in South Africa

Background

South Africa is one of the world's largest minerals-producing nations. In 1996, South Africa accounted for 40 per cent of the world's gold and 56 per cent of the world's platinum supplies. The direct contribution of the minerals industry to gross domestic product (GDP) was 8.1 per cent in 1996, with the significance of the minerals industry increasing to 15 per cent of GDP once indirect contributions are included. South Africa's mining industry has been compromised by increased costs associated with work disruption, workplace inflexibility, technical problems related to deep-level gold mining, declining ore grades and declining productivity. Despite those constraints, primary mineral exports accounted for 38 per cent of South African merchandise exports in 1996 (South Africa Chamber of Mines, 1997).

Policy changes and implications

Minerals policy within South Africa is currently undergoing wholesale restructuring. Although many measures implemented during the apartheid era remain in place, much proactive policy is being implemented by major mining companies. Among significant issues faced by the new Government is a policy to promote resource access for those previously facing discrimination. Equally significant for future policy is the need to ensure enabling macroeconomic and legislative environments in which mining can be profitably carried out. To maintain a strong domestic industry during the current phase of globalization in the minerals sector, South Africa aims to ensure that fiscal, legislative and operating environments remain internationally competitive (South African Chamber of Mines, 1996). Significant policy issues are described below:

Ownership of resource rights not held by the State have in the past been dictated by a combination of Roman-Dutch law and racial circumstances. Recent changes in ownership policy have sought to reduce that racial bias of ownership. The new Government of South Africa has explored the complete abolishment of private ownership of mineral rights, but that idea has met with resistance from the mining sector, and exchange of minerals ownership has to date met with little direct success.

The South African Chamber of Mines notes the need to lower *barriers to entry* in the minerals sector and facilitate effective use of the 1991 Minerals Act, which enables government intervention in the case of activities deemed to be against the national interest.

South Africa treats *foreign investment* in the minerals sector in a similar manner to domestic enterprise, and permits 100 per cent ownership. Import surcharges on capital goods have been eliminated. Currently, foreign direct investment in mining only accounts for less

than 2 per cent of GDP, reflecting the reduced profitability associated with gold mining, significant tariff reductions in other sectors and the termination of protective policies.

Government tax receipts from mining during 1996 were in excess of 1.8 billion rand. A move away from revenue to profit-related taxation, together with possible concessions relating to South African minerals demarcation, should provide a mechanism for encouraging new investment in minerals. The Government has pledged not to increase tax in real terms since it aims to remain internationally competitive (South African Chamber of Mines, 1996).

Profit sharing through increased wages was agreed in June 1997. The package was conditional on the implementation of full calendar operations. To date, that system has not been fully implemented but it is expected to significantly increase minerals productivity.

Mining companies are now investing more in the *education* of adult workers. Not only are educated miners more productive, but such education will also further enhance national education levels and empowerment.

The Mine Health and Safety Act of 1996 imposes the responsibility for *health and safety* at mines on owners and managers.

E. Strengthening civic institutions

39. Civic institutions – those that promote education, training, community organization and the dissemination and public availability of information – play a central role in improving a country's capacity to maximize the benefits from mineral production. By providing an interface between government, communities and industry, those institutions represent a significant forum for dialogue and stakeholder participation in decisions relating to mineral development. Support for those institutions can facilitate decentralized, bottom-up initiatives to harnessing the developmental benefits of mining activity. Such initiatives, if developed through local participation and supported by national Governments, can represent an alternative to the extensive use of national, regulatory approaches to capturing economic and social benefits.

40. By involving stakeholders more effectively in participation from the outset, civic institutions not only further the development of local capacity but can also promote collaboration and cooperation as alternatives to political confrontation between industry, government and communities. The recent increase in mineral investment in developing economies provides an opportunity to develop creative partnerships at the local level to integrate mine development into a wider regional strategy for improving economic and social conditions. The creation of partnerships to promote increased capture of the benefits of mineral production can be facilitated through the development of common tools and methodologies for measuring progress towards sustainable development in mineral economies. By collectively developing and implementing indicators for economic, social and environmental performance, for example, Governments, industry, non-governmental organizations and development agencies can create a common framework for measuring and evaluating the benefits of mineral extraction.

41. Education and training are essential components in the development of a country's capacity to increase economic and social benefits from mineral extraction and processing. As an investment in human capital, education and training can foster the development of the skills and capacities necessary to participate in the minerals sector. In addition, training and education can improve the resiliency of local communities to fluctuations in mineral activity by emphasizing the development of skills that are transferable beyond the mineral sector. For example, the Jackpile-Paguate Mine, located on the Laguna Pueblo Native American Reservation in New Mexico, initiated a programme of cross-training to develop skills and expertise to be used locally once the mine closed. Mine workers were provided with training in construction, earthmoving and business activities, so that once production ceased Laguna Pueblo had developed sufficient local capacity to go into business as a regional contractor. Laguna Construction is now one of the largest Native American enterprises of its kind, specializing in land reclamation, hazardous waste management and construction (MERN, 1996c).

IV. Recommendations for developing capacity

42. Innovative policy approaches are required if the capacity of developing and transition economies to maximize economic and social benefits from minerals development is to be improved. Analysis of the challenges and opportunities arising from the particular characteristics of mineral economies demonstrates the importance of developing mechanisms and institutions able to minimize the potential for economic and social disruption while maximizing potential returns from new investment. The feasibility of adopting specific mechanisms to encourage the development of capacity will vary from country to country and even from one mineral project to another. Mechanism design and implementation, therefore, needs to be attentive to structural differences between developing and transition economies, as well as to differences between countries within each group. Variation in mineralogical, economic, social and political conditions suggests that blanket prescriptions for capacity-building in developing and transition economies are unlikely to be effective. It is possible, however, to identify the generic elements for successful policy approaches to increasing the capacity of mineral economies to maximize the benefits of mineral production. Those elements are:

(a) To facilitate opportunities for investment, employment and capacity-building by reducing levels of political risk to new investment through the development of appropriate mining laws, a competitive tax system, and transparent, enforceable regulatory codes;

(b) To increase the feasibility and opportunities for success of efforts to build capacity by developing innovative approaches to manage the volatility of revenue streams in mineral economies;

(c) To promote education and training to foster the development of the skills and capacities necessary to participate in the minerals sector; promote cross-training and education to improve the resiliency of local communities to fluctuations in mineral activity by emphasizing the development of skills that are transferable beyond the mineral sector;

(d) To facilitate innovative approaches to harnessing the benefits of mineral production by, for example, assessing the full range of potential benefit streams to local economies in addition to mineral revenues, examining the opportunities for leveraging mining projects to increase social investment, and promoting links between mineral projects and regional development priorities at all stages of the mineral production cycle, from exploration through development and production to closure and reclamation;

(e) To foster the development of the technical and managerial capacities of regulatory agencies in developing and transition economies by promoting cooperation between industry, government and local communities, developing common methods of evaluating the impact of mineral development, and strengthening the role of international agreements on social and environmental performance;

(f) To develop policy approaches to address the specific concerns of the small-scale mining sector by, for example, clarifying the rights, title and access of small-scale miners to mineral deposits, and by developing programmes to enhance the technical and organizational capacity of the small-scale mining sector;

(g) To support participatory approaches to the development of local capacity through the promotion of programmes that facilitate consultation and dialogue between mineral project stakeholders from the outset, encouraging central government support for decentralized, bottom-up initiatives to improve capacity, and the development of common frameworks for evaluating and assessing the socio-economic and environmental impacts of mineral operations in terms of their contribution to sustainable development.

Notes

[1] See, for example, North (1955) and Tiebout (1956).

[2] See Hirschman (1977) and Auty (1993).

[3] See, for example, Auty (1993), Gelb (1988), Sachs and Warner (1995) and the analysis by Innis (1956) of the "staples trap" for natural resource economies in Canada.

[4] Mineral economies can often exhibit what Freudenburg and Gramling (1994) term "overadaption", specialization in extractive employment that makes it difficult to consider alternative forms of enterprise and that can deter alternative forms of capital investment.

[5] See, for example, Freudenburg's (1992) analysis of extractive communities and his conclusion that extraction can lead to economic addiction.

[6] It must be recognized, however, that asset depletion can be very significant at the subnational level, particularly for individual communities based on a single mine.

[7] Such volatility derives in part from the capital-intensive nature of the production function for mining, which reduces the flexibility with which firms can respond to price swings. Its impact on revenue streams is illustrated by reference to the increase in the average export price for copper in Chile from 56c/lb in 1986 to $1.05/lb in 1988, which had the effect of doubling the profit of the Corporación Nacional del Cobre

de Chile to $267 million in 1986-1987 and increasing it to $1 billion by 1988 (Financial Times, 1988, cited in Auty, 1993).

[8] "Dutch disease" results from the strengthening of the exchange rate as a consequence of the over-rapid inflow of mineral revenues into the domestic economy. In some cases, such as Mexico, Venezuela and Nigeria during the 1979-1981 oil boom, virtually no non-mining activity remained internationally competitive (Auty, 1993). Analysis has shown that the effect of Dutch disease in weakening the non-mining sector is exacerbated by the fact that the compensating expansion of the non-mining tradeables sector during downturns in mineral prices is hesitant at best (Auty, 1993; Krugman, 1987).

[9] For example, in response to the debt crisis (US$7 billion in 1995) and pressure from international lending organizations, the Government of Zambia embarked on a liberalization programme following the first multi-party elections in 1991. The primary objective of liberalization has been to stimulate economic growth by promoting a stable and open investment environment. The package of reforms has included the privatization of Zambia Consolidated Copper Mines.

[10] Corporación Minera de Bolivia (COMIBOL) is the company in charge of managing Bolivia's interest in all state-owned mining concessions, metallurgical and industrial plants. According to the new mining code, COMIBOL cannot directly operate any mining, metallurgical or industrial operation. COMIBOL will look after the state's interest in those operations only through joint venture, lease and/or service agreements with private entities. The Vinto smelter is the fourth largest tin smelter in the world, and its capitalization is estimated to attract investment of US$ 50-100 million (see United States Department of Commerce, National Trade Data Bank, September 1997).

[11] Privatization of mineral assets worldwide (excluding the former centrally planned countries) raised over $2.2 billion in 1995, twice that of 1994. Bolivia, for example, began privatization of state industrial assets in 1985, Venezuela initiated privatization in 1994, India opened up 13 minerals industries to private investment in 1993, and following an unsuccessful attempt in 1992, Peru renewed its efforts to privatize CENTROMIN in 1995 (Warhurst and Bridge, 1997).

[12] For example, in 1995, foreign direct investment in developing countries was valued at $90,000 million, while capital expenditures on mining alone were estimated at $20,000 million for the period 1995-2000 (Mining Journal, 1996b).

[13] These projects include Lihir, Porgera, Misima, Tolokuma and Ok Tedi. Mining and petroleum represent 72 per cent of the country's export earnings, and account directly for 25 per cent of its gross domestic product (Mining Journal, 1996a).

[14] Based on Hemingway (1991).

[15] See, for example, Laitos (1991) in connection with environmental conditions attached to oil and gas leases.

[16] It is important to note that although foreign direct investment has increased in the minerals sector, its destination is limited geographically to a relatively small number of countries, and furthermore to particular firms within those countries.

[17] Based on Cooney (1996).

[18] South Africa, however, has traditionally had a very different ownership structure with an estimated 90 per cent of mineral rights belonging to private landowners; that structure is currently under review (see case study).

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Issues related to the spatial planning of land (including minerals) and water resources

Report of the Secretary-General

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I. Introduction

1. The present report has been prepared pursuant to Economic and Social Council decision 1996/306.

2. Section II of the report identifies emerging issues in the area of land and water resources management, and places human-induced stress in the context of finite land and water resources; section III puts forward recommendations for improving the spatial planning of land and water resources.

II. Current and emerging management issues

3. Air, water and land ecosystems are intimately linked, a linkage that often comes into sharp focus when environmental balance breaks down irretrievably as a result of accelerated erosion, salinization, groundwater pollution and other similar processes whose damage goes well beyond the original source of degradation. The linkage is clearly recognized by the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, which stresses, *inter alia*, that the major threats to the health and productivity of the marine environment result from human activities on land in coastal areas and further inland. Similarly, the Food and Agriculture Organization of the United Nations (FAO) Interdepartmental Working Group on Land Use Planning defines land as a delineable area of the earth's solid surface, embracing all attributes of the biosphere above and below the surface, the soil and underlying geology, the hydrology, plant and animal populations and human settlements, and the physical results of past and present human activity. This not only highlights the interdependent nature of land and water, including lakes, rivers, wetlands and groundwater processes, but also points to the high degree of variability in resource availability.

4. Although human influence on land and water resources play a major role in many regions, it also should be seen against the background of natural processes, such as erosion and chemical cycles. Anthropogenic degradation in the form of erosion, salinization, waterlogging, depletion of fossil groundwater, pollution by non-degradable chemical substances, acidification and eutrophication have socio-economic consequences that include a decrease in land productivity for long periods of time and the need to implement costly restoration programmes. Waterlogging and associated salinization of land caused by irrigated agriculture in arid and semi-arid zones result in significant losses of agricultural land each year. In addition, land and water degradation often set off a chain of complex problems. Soil erosion leads to both the depletion of nutrients and reduced water-holding capacity, which may in turn cause siltation of river systems and reservoirs. Not only does this reduce the lifespan of reservoirs, but their reduced storage capacity may also increase the risk of flooding. If reservoirs do not act as traps for suspended material, enhanced erosion may also threaten lacustrine and marine ecosystems.

5. Mining and smelting industries have created local environmental effects throughout the world, and in the past have led to acute or chronic toxication. The effects of mineral exploitation on land and water systems depend upon a variety of factors, such as the chemical composition of the minerals, topography, methods of mining (open pit or underground mining), hydrological conditions and climate. The environmental effects of mining often extend far beyond the mining site in terms of, for example, changing groundwater flows, pollution of surface and groundwaters, deposition of wastes and windblown dust. The most serious problem is the release into the environment of harmful trace elements and heavy metals, such as lead, cadmium, arsenic and mercury, which may not only pollute local and regional water resources but can also degrade large land areas, major aquifers and eventually coastal areas. Harmful concentrations of metals can also build up in associated plant and animal life and move up the food chain to affect human health. Heavy metal pollution of water has a number of anthropogenic sources, including mining, processing of ores and particularly leaching from industrial waste dumps and mine tailings. Acidified or saline water enhances metal mobility and draws more heavy metals from mine tailings. It also transforms such metals as lead into a form more readily absorbed into living tissues, thus amplifying the toxic effects of leaching. Pollution of groundwater due to leaching processes, particularly in areas with sulphide ore deposits, can be especially serious since reclamation of the affected aquifers is technically demanding and expensive.

6. Land and water issues are multidisciplinary and include a large number of other environment and development issues, such as desertification, deforestation, biodiversity, air and water pollution, agricultural development, rural and urban development, climate change and sea level fluctuations. Although these clearly call for an integrated approach, such issues are often addressed independently, resulting in duplication and waste of financial, human and institutional resources.

7. Broadly speaking, agricultural land (and land in general) cannot be considered a fully renewable resource since in many ways it is finite. The total land area of the world is estimated at about 13 billion hectares, over half of

which lies in developing countries. According to FAO estimates, only about one tenth of the land area in these countries is currently used for crop production, and much of the agricultural land in industrialized countries is already in production. It is also estimated that 90 per cent of potential new crop land is located in the developing world, of which 95 per cent lies in Africa and South America, while the remaining 5 per cent lies in Central America and the Middle East (virtually no land is available for expansion in Asia). In any case, a considerable proportion of this "land reserve" is under forest or in protected areas, and cannot really be considered as readily available for agricultural expansion. Other constraints to agricultural expansion include conflicts over land tenure and inadequate allocation of land rights, lack of access to both credit and adequate agricultural inputs, and high costs of transportation and land clearing. In addition, approximately half of the 1.8 billion hectares of land in developing countries (excluding China) with rainfed crop potential is located in humid areas (that is, too wet for most crops and rather unhealthy for human settlement) or is considered only marginally suitable for crop production. The possibilities for expansion of land for crop production are, therefore, relatively limited. Nonetheless, it is generally accepted that world food supplies will have to double between 1995 and 2025 because of continued population growth and expected rises in income. However, in view of the constraints on future land supply, unlike previous decades when expanded land area and increased irrigated area played a major role in increasing agricultural production, most of the rise in future production is expected to come from biological yield increases (that is, the intensification of production with high-yielding crop varieties) in high-potential areas.

8. According to recent FAO estimates, while arable land may expand by 90 million hectares by 2010, the harvested area could increase by 124 million hectares because of rises in cropping intensities, with irrigated land in developing countries expanding by 23.5 million hectares from the present 186 million hectares. As a result of intensification of land use in areas that are naturally well endowed or can be made so by economically viable human activities, such as irrigation and drainage, there will be a significant decrease in the average rate of land per rural household in the near future. Per capita availability of arable land in developing countries is projected by FAO to nearly half between the late 1980s and 2010, from 0.65 to 0.4 hectares, and that figure is likely to decline even further towards 2050, when the possible adverse impacts of global climatic change on food security may become more accentuated. By contrast, the per capita amount of arable land may increase in industrialized countries given their relatively stagnant population growth. This is likely to lead to the more marginal arable lands being taken out of production as "set-aside" lands for nature development, cultural landscape conservation or recreational purposes. The situation in countries with economies in transition is more difficult to project because of the current process of the transfer of state-owned arable land to private ownership.

9. A significant part of the world's agricultural land suffers from soil degradation, salinization, desertification and waterlogging, not to mention scarce availability of water for irrigation. Moreover, the main components of land may degrade in their intrinsic quality or economic value not only as a result of inappropriate human activities but also as a result of natural processes, such as earthquakes, volcanic eruptions and the effects of climate variability. Furthermore, degradation of one component, such as human caused deforestation, can negatively affect other components, such as soil, water flow or humidity. Soil degradation is probably the most widespread and serious form of deterioration, because (a) it undermines a major life-supporting system, (b) its natural recuperation may take decades or centuries, and (c) artificial soil rehabilitation is often very expensive. It is estimated that one fifth of current irrigated land in the world is already degraded to the extent that crop reproduction is significantly reduced. The most important cause of soil degradation is overgrazing by livestock, although deforestation, unsustainable land-clearing activities and inappropriate agricultural practices have been major contributory factors in the process.

10. Economic growth and urban development will lead to further competition among various users for scarce land and water resources. Agriculture will continue to be the most important economic sector and represent the most important user of these resources in many developing countries, including some countries with limited availability of water resources. Hence, policies and programmes affecting the allocation of land and water among competing uses can have a profound impact on urban and rural development, and on the generation and distribution of economic benefits.

11. The economic and social aspects of the interaction between land and water resources are among the most neglected areas of economic and social policy. The perception of land and water resources as free environmental goods has resulted in their true values being underestimated, often leading to inefficient exploitation and environmental degradation. The often perceived result is sub-optimal allocation and market, policy and institutional failures that are widely documented.

III. Actions to improve and enhance the spatial planning of land and water resources

12. Water and land resources are so closely intertwined that a purely sectoral approach to the planning, development and management of either resource should be avoided since this may lead to their irreversible degradation. Concern about the environmental dimension of both land and water use has been highlighted by rapid world population growth, widespread land and groundwater degradation, ecological interdependencies at both national and regional levels, the growing awareness of the value of natural ecosystems and even the perception that land-use practices may influence the global climatic system. An integrated rather than sectoral approach is essential to prevent or resolve conflicts related to land and water use, since it optimizes the overall planning process and creates an enabling environment for mediation between, and decision-making by stakeholders at all stages of the planning and implementation process. In addition, another major source of conflict that must be addressed through integrated planning and management is competition between urban and rural land uses. This conflict can be expressed in various forms, such as (a) expansion of human settlements, industrial areas and peri-urban infrastructure versus protection of prime agricultural land and safe agricultural land tenure, (b) mass influx of rural poor to urban areas versus adequate availability of labour for agricultural activities (or conversely, urban unemployment), (c) competition between urban and rural water use, and (d) urban demand for timber and charcoal versus vegetative protection of upper catchments to prevent the degradation of agricultural land and water resources.

13. The report of the Panel of the Commission on Science and Technology for Development, submitted as a background document to the Inter-sessional Working Group on Sectoral Issues at the fourth session of the Commission on Sustainable Development, concluded that most of the scientific knowledge and applied technology needed for effective land resources management are available. The same is true for water management, and it is likely that countries with such problems may not be applying this knowledge effectively due to limited access to information and appropriate technologies, lack of adequate infrastructure to use available technology efficiently and institutional fragmentation, which result in uncoordinated approaches and efforts, lack of scientific and educational capacity, problems caused by current land-use practices, and unresolved conflicts between different land-use goals. In addition, the lack of human financial and organizational resources in many countries prevents people from actively participating in environmental management and policy development.

14. All countries are facing various degrees of land degradation problems, and examples of progressive practice in land and water management can be found in different climatic and physiographic zones (see box 1). In addition, numerous international conferences, papers and national experience have provided basic frameworks on which to build effective management plans. It remains a challenge to implement such knowledge into policy planning, establish the national capacity needed, identify actors, coordinate various efforts, provide an updated and accurate knowledge base, and provide the necessary financial resources.

15. There is a continuum of actions required at all levels in order to move towards overall sustainability of land and water resources. At the global and regional levels, issues to be addressed include desertification, drought and flood management, as well as other issues related to natural disaster reduction. At the regional level, there is also scope for actions to control transboundary pollution of soil and water, cooperation in the conservation and use of international waters (rivers, lakes and groundwater) and river basins, and the transfer of technology and know-how. At the national level, there is a need to implement policies to promote the sustainable use and management of land and water resources, including with regard to the identification of clear rights to land and water resources. Significant action also needs to be taken at local levels, where local development plans should aim at efficient and sustainable use of existing resources, protection of resources from quality degradation, and strengthening of local participation, especially by women and the poor, through education and public awareness campaigns and greater opportunities for local participation in planning and decision-making processes. A number of issues need to be addressed to ensure an effective integration of land and water resources management.

A. Integration of land and water resources management into national socio-economic strategies

16. Effective land and water resources planning, development and management needs to be integrated into overall national economic and social planning and strategies. National and regional development plans should also recognize that integrated land and water management policies can only succeed if they are based on broader

Box 1. Integrated land and water conservation in Keita, the Niger

Before the start of the Keita Integrated Rural Development Project, the Keita valley in the Niger was in a dramatic situation as a consequence of frequent drought years: the vegetation had almost disappeared over most of the plateaux and the "glacis" (large areas, with gentle slopes, located at the foot of valley slopes). The sandy slopes were eroding fast under the surface run-off, and the beds of the ephemeral rivers had become deeply entrenched as a consequence of water erosion. The floods that had once provided necessary moisture to the surrounding land and were used for cropping staple food no longer occurred. Now the plateaux and glacis have largely been reclaimed through water harvesting techniques consisting of building anti-erosion bunds, subsoiling and impluvium: water runs off the bare soil on to the cultivated plots below, in alternative strips parallel to the contour lines. The harvest that had disappeared is now fully restored.

River run-off occurs as high intensity flash floods of short duration. In order to attenuate its destructive effect and improve control of the overall flow pattern in the hydraulic network, the tops of small watersheds of less than 20 km^2 are controlled by building earth check-dams of lateritic material, equipped with a gabion reinforced lateral spillway, and in some instances a pipe traversing the earthen dyke. These dams capture the peak of the flood, store it temporarily and release the water over a much longer period at a low rate, which has the advantage of reducing the erosive force. The check-dams form water impoundments that last several months after the short rainy season, and provide a valuable asset for farmers and livestock. They also recharge the groundwater and in some instances allow fish farming. As the impounded water recedes during the dry season, the farmers sow off-season crops: onion, sweet potatoes, maize and even wheat and sunflower.

In the large main watercourses or "koris", floods of several hundreds of cubic metres per second do not allow the building of storage dams by using the simple techniques applied in the upper watersheds. However, in order to restore the severely eroded stream beds to their original level and slow and attenuate the flood peaks and conserve the water table, the project has erected gabion dykes one to two metres high and several hundreds of metres long across the whole of the kori bed in order to restore large-scale seasonal ponds that once formed every year but disappeared during the drought years under the effect of erosion. This has now restored the flat pond areas, which are also used for producing flood recession crops as above. Another beneficial effect is the rising of the water table, where shallow wells can be dug for more horticultural crop production. For a number of years, a hydrological network has been in place in order to measure rainfall and river run-off. Up to now, the effects of the conservation work which have been carried out are clearly visible, but it is too soon to know what the long-term outcome will be.

catchment and basin strategies. Moreover, it is increasingly clear that conventional options for purely administrative solutions to land and water management appear to have reached their limits. A consensual approach to natural resource management is thus becoming an increasingly attractive solution for resolving tensions between owners, managers and regulators of resources.

17. Any policy formulation and implementation should thus involve all stakeholders as early as possible in the process, and should include those that are affected by any action, those who possess knowledge and expertise, and those who control the relevant instruments for successful implementation of policies and actions. The focus of the problem may be global, since all regions of the world to some extent suffer from various types of degradation problems, but national Governments have the main responsibility for dealing with national degradation problems, possibly with support from the international community. In addition, it is important to recognize the areas that need special attention, including irrigated lands, drylands, areas with large seasonal variations in precipitation, areas experiencing extensive deforestation, and mountains and other areas with a steep topography.

18. Estimating the full economic value, including environmental and amenity assets, of land and water poses particular problems, and a range of solutions have been employed by economists and their respective institutions. Some examples on how to place a value on the public good benefits of water are discussed in a recent World Bank report.[1] Economic valuation of water-related investments in development and management of irrigation, hydropower, urban and rural water supply and sanitation, drought prevention and flood control is important because it aids in determining the worth to people of proposed projects and in estimating the degree to which they are willing to pay for benefits. In the prevalent situation of constrained public budgets, conceptually correct and empirically valid estimates of the economic contribution of both land and water in each water-using or land-use sector are essential for making economically sound investment decisions.

B. Land, water and food security

19. Greater attention needs to be given to the vital role of land and water resources in food production. It can be argued that there are at least three crucial preconditions required to close the threatened gap between food production and consumption: sustainable water development, appropriate government policies, and an educated labour force with high-quality technical support. These three conditions are evidently linked. Water shortage is becoming a critical development constraint. Water resources, which until quite recently were considered cheap and plentiful, are now fully recognized to be relatively scarce and valuable. Good governance, including the maintenance of local and regional security as well as sound macroeconomic management, is necessary to promote agricultural investment and its profitability. Sustainable agricultural development requires a range of production inputs and profitable markets. Productive agriculture also requires a wide range of technical skills, including water management skills and specialist support, either in the public or the private domain. Furthermore, as clearly expressed in a recent Economic and Social Council review and analysis of agrarian reform and rural development (see E/1996/70), it is increasingly recognized by United Nations Member States that the market (even if regulated) is the most effective land distribution mechanism. The market is also generally seen as the most appropriate means for reducing unequal patterns of land distribution and for promoting more efficient land use, although experience shows that corresponding participatory and democratic policy interventions reforms and effective regulation are also necessary.

C. Land, water and health

20. With water as a primary agent in maintaining human health and transmitting disease, there is an imperative need to manage land and freshwater sources to maintain chemical and biological quality to minimum acceptable standards. Key actions that will work towards the protection and improvement of water quality include (a) priority for sanitation, sewage treatment and control of discharges of industrial effluents and run-off of pesticides and fertilizers, (b) monitoring of bacteriological and parasitic water-borne diseases at the basin level, and (c) prevention or minimization of contamination of land and water by heavy metals and other chemicals.

D. Protection of land and water ecosystems

21. The balance between environment and development needs to be founded on a clear understanding of the environmental systems and the resources that they can furnish without compromising their overall long-term integrity. The economic implications of environmental degradation and ignorance of climatic variability can account for significant percentages of gross domestic product in lost productivity. As mentioned above, a number of environmentally sound development policies to avoid or mitigate damaging impacts on land and water ecosystems

have been formulated by various national and international bodies, including the body of recommendations related to the implementation of United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly in Africa, the Convention on Biological Diversity, the Convention on Wetlands of International Importance, Especially as Waterfowl Habitat (Ramsar Convention) and the United Nations Convention on the Law of the Non-Navigational Uses of International Watercourses.

E. Information management and monitoring systems

22. The continuous monitoring of environmental changes is crucial for economic and social planning at both the national and regional levels. The adaptation to changes (natural as well as human induced) that take place in the landscape requires that information on such changes be periodically gathered and analysed. It is useful, however, to note that the financial costs of establishing, operating and maintaining monitoring systems can be high and beyond the means of many developing countries unless financial (and technological) assistance is provided. This calls for careful cost-benefit analyses that take account, *inter alia*, of the limitations of these systems and the possible benefits that they will provide, including (a) the provision of adequate and accurate information to decision makers, (b) the ability to detect changes in the landscape, including natural or human-induced disasters) so that appropriate measures can be taken to deal with them, and (c) the ability to detect natural and man-made disasters so that appropriate action can be taken to prevent them or the mitigating effects that follow them.

23. Disasters, natural as well as human induced, are often related to land and water systems, such as floods, droughts and mud-flows. When they occur, there is a need for rapid and coordinated responses and actions from local, national and international organizations. If data and information are available and continuously updated, changes that may eventually cause a disaster, such as deteriorating water and soil quality (including salinization), changes of the groundwater table, top soil loss, floods and mud-flows, may be detected and actions can be undertaken in advance. When disasters occur, communication systems and infrastructure are often severely damaged, which means that coordinated actions can be difficult. In many cases, remote sensing has proven to be the only tool for keeping rescue workers and planners continuously informed on the emerging development. National and regional capacity to gather and evaluate information that is relevant to disaster prevention need to be strengthened, including through international financial and technological assistance, if required.

24. Any monitoring programme developed to study relationships between land and water needs to be cross-sectoral, both within the scientific community and between researchers and policy makers, in order to present a comprehensive set of policy options to decision makers. Comprehensive studies on the reasons behind poor land and water management practices should not only focus on physical constraints in the environment but should also examine pricing policies, land access issues, subsidies, taxes, environment laws, the role of land and water resources in social and economic development, local customs and indigenous knowledge. There is also a need to have an open discussion on further data needs and how to integrate information systems to better address environment issues related to land and water management. The question of addressing issues from a river basin perspective fall into this category. Organizations and Governments have ambitious programmes but information, if available, is often scattered and sectoral, which makes it difficult to prepare detailed assessments and propose effective management strategies. It is also important to define data and information needs for each country and region within countries since areas with a complex and changing environment or where land use is intensive will require dense monitoring systems, while more homogenous and sparsely populated areas may require less coverage.

25. The overall objective should be that countries and international organizations enhance ongoing efforts, both national and international, to collect and analyse data and information about the physical, social and economic environment that can be applied to the watershed level (or any other appropriate spatial level). Financial and technical assistance should be given to developing countries to formulate and implement national programmes in the area of data collection, analysis and exchange. National geographical information systems should be particularly developed and supported, and their databases should be systematically updated and expanded, as required. Scientific cooperation among universities could be one step in the right direction. It could be possible from this system to retrieve information and data sets on physical, social, economical and environmental conditions and parameters, and to integrate them at the desired spatial scale, for example covering a specific river basin or sub-basin.

F. Institutional and legal framework and capacity-building

26. In order to implement integrated land and water policies, countries need to define appropriate spatial and temporal scales, at both the national and local levels, for the formulation and implementation of relevant development and conservation programmes, including monitoring systems. It is important to recognize that although the basic problems of land and water management have many similarities around the world, local variations in the physical environment and social and economic conditions require that technological and managerial solutions be adapted to local conditions.

27. Large river basins may not be amenable to single basin management approaches developed for small-scale basins or sub-basins. It is important, however, that national (and to some extent regional) planning take into account the river basin as a natural planning unit. As a first step, this can be done within existing institutions, by coordinating planning strategies and adapting them to the required spatial level. This process would be facilitated by establishing a focal point within national and subnational administrations. In addition, there is a need for political initiatives and economic incentives that promote consultation and coordination among the actors. Despite the fact that interdepartmental coordination within national and local administration would be an important step in making land and water management planning more efficient, the efficient integration of land and water resources may require the establishment of catchment organizations that would have a responsibility for planning from the main catchment level down to smaller "tributary units". This need to establish efficient water authorities and river basin plans was in fact already clearly recognized in 1977 at the United Nations Water Conference at Mar del Plata, Argentina.

28. Local (tributary) organizations should also be given a high degree of responsibility over the planning and use options of land and water resources under their jurisdiction, including the solution of conflicts among competing different water and land uses. If not already available, an inventory of local land and water resources should be compiled, and the social, economic and environmental requirements of all stakeholders need to be identified. Based on these assessments, basin organizations should develop different use options that aim at sustainable development in the long run. To have effective authority, basin organizations need to be empowered through national and local legislation and to have some means of financial autonomy. Provided that formal agreements are made among riparian States, an overarching river basin organization might deal with issues at the international level, that is, the sharing of water between countries, transboundary pollution, policy issues, technology transfers and financial issues. Another important task would be to seek ways of harmonizing policies, strategies and programmes so that similar, effective mechanisms from one area could be implemented elsewhere as needs arise. Both this overarching organization and local tributary organizations will need access to adequate physical, social and economic data in order to make appropriate and well balanced decisions.

29. It is important to initiate country-driven pilot projects that address the comprehensive nature of land and water resources systems and demonstrate the strong linkages that occur between such systems. The above-mentioned organizations, in cooperation with national Governments and international organizations, could have an important role in identifying such programmes, drawing up plans and initiating their implementation. The Committee on Natural Resources, at its third session, in 1996, urged Governments, with the support of the organizations of the United Nations system, other multilateral and bilateral organizations, and non-governmental organizations, to consider the possibility of establishing pilot projects on river basins and regions that were deemed to be suffering from serious water-related stresses with a view to developing and implementing policies designed to avert a water crisis.

30. Worldwide, there are four common threads to be found in river basins where integrated planning and management of land and water resources are rated as effective. First of all, a stable institutional framework that overcomes fragmentation and overlap of responsibilities, and is supported by comprehensive but flexible legislation and regulations, must be in place. This ensures fairness in basin-wide decisions and a process of accountability. Second, planners and stakeholders should have access to a strong knowledge base based on an accurate and comprehensive data network that allows the formulation, implementation and follow-up of sustainable natural resources development strategies. This ensures equity in defining solutions among and between the implementing agencies and water users. Third, full integration across all natural resource issues must be carried out, which implies that individual agencies look at impacts and improvements across the spectrum of natural resources. It also means that provincial and regional governments look at their natural resources base as a whole and attempt to achieve sustainability as a package, as opposed to attempting to maximize use of a single resource, such as water, soil or minerals. Last but not least, a programme for strong community awareness and

participation should be fully implemented. Most policies or decisions relative to the rehabilitation or exploitation of natural resources have a large impact on users, especially farmers. Unless the farmer understands these issues and is able to provide inputs into the decision-making process, users cannot be expected to give up some use or activity for the so-called common good. This is where it is important to find a "win-win" solution for all concerned, but particularly the farmer.

31. Within the river basin organization, two other components are essential for a sustainable, efficient and effective management. First, the organization must have its foundation and mandate in legislation that clearly identifies its functions, structure and financial base, and its operation must be based upon a decision-making process of authority, responsibility and accountability. Every decision made by a higher level body to be carried out must not only delegate responsibility but also commensurate authority and financial capacity. And every decision that is carried out by the lower-level body requires accountability of the action taken to the higher level body, through a systematic reporting process. If that process is properly carried out, the organization must internally carry out a planning, programming and budgeting system in which the operational body at the lower level will submit for consideration a plan, programme and budget for the higher-level policy and decision-making body to review and approve. Second, the organization must be conceived in the reality of existing conditions, where there are already vested interests, attitudes and economic bases; that is to say, there may (are) be already water and other resource agencies with similar mandates, but which operate along administrative or other jurisdictional boundaries, attitudes with respect to location and accessibility to water resources (upstream-downstream mentality), and current water and land uses and practices. Whenever and wherever reform movements of the nature and magnitude of comprehensive river basin management are introduced or expanded, there is resistance to change and concern over infringement on administrative level and agency "turf". To mitigate such resistance and ensure a successful reform (although this may take many years), it is necessary to adopt a strategy of communication, coordination and cooperation within the river basin organization and among the appropriate levels of government, agencies, water users and the community.

32. Relevant chapters of Agenda 21 recognize that many of the problems related to land and freshwater have arisen from a lack of adequately trained personnel, public awareness and education about surface and groundwater resources protection. Since extension services have traditionally been provided by sectoral institutions without proper coordination, starting to build the institutional capacity to deliver integrated services at the field level requires, above all, both high-level ministerial policy coordination and appropriate financial and human resources. Applying a multidisciplinary mix may need a refocusing of efforts at intermediate institutional levels and extensive retraining of extension officers. These efforts should ideally be supported not only by international, national and local support agencies, but also by the private sector and various non-governmental and scientific organizations.

33. The strengthening of institutional capacity also requires a strong educational, research and analytical infrastructure, primarily based on local and national expertise. Educational capacity needs to be built from a strong base, including primary education. At the national level, considerable efforts need to be made to promote the understanding of interactions between land use and management on the one hand, and quality and flow regimes of river systems and groundwater on the other. This is particularly important in rural areas, since non-point sources of pollution, including fertilizers and various toxic substances used in agriculture, is an increasingly serious problem worldwide. The scientific community, through universities and international organizations, has a responsibility to gather and present information that is accurate and comprehensive, and to provide practical assistance in the implementation of action-oriented programmes and initiatives. At the same time, Governments should promote and enhance the active participation of scientists in the policy and decision-making process.

34. As a complement to education programmes, public information campaigns are an important way of communicating with large groups in society. These campaigns should be based on information that is readily available and comprehensible to the general public, and should aim at promoting broad public interest in environmental issues. It is important that such campaigns be presented in a positive manner, demonstrating possible development options of interest to people at the local level. The technical revolution within the information and communication media (that is, the Internet), has enabled the cheap dissemination of vast amounts of information on these and other environmental issues. This, however, has not yet benefited a majority of the population in developing countries that presently lack the means to access these services. In order to be disseminated worldwide, assistance to develop national networks in developing countries is urgently needed.

35. Considerable attention has been paid to gender issues in some sectoral uses of water, specifically in domestic water

supply and sanitation. However, gender issues in the broader picture of land and water resources management have received much less attention. At the operational level, women are too often seen solely as users of domestic water and as a pool of volunteer labour with unlimited time and energy. Women are rarely treated as managers of water and land resources. Failure to encompass the diversity of water users, uses and institutions, combined with non-consultative processes of land and water allocations, have led to negative impacts on women, their families and the communities, and conflicts over water and land. The main constraints that women confront in achieving full integration and participation in water resources management are: (a) lack of education and training, (b) lack of participation in planning, programming and projects, (c) lack of information and awareness-raising methodologies, (d) lack of financial means, and (e) lack of choice of various types of technologies.

G. Transfer and adaptation of technologies

36. The efficient management of land and water resources is mostly a local or national issue, and will need to be defined for each area. Local and indigenous experience can be an important source of knowledge that is often ignored in traditional technical cooperation arrangements. Research into and adaptation of such knowledge for contemporary application can yield results that are cost-effective and sustainable. It is also important that technologies and training or education programmes be adapted to local conditions and local users. Appropriate technologies to improve land and water management exist, but their applications are limited by institutional and financial constraints, as well as lack of appropriate training and education. Transfer of technology is not automatically a solution to the underlying problems facing many countries, such as increased population pressure and land degradation, but can be an important component in combination with many other actions that might be needed, including measures to ensure adequate operation and maintenance at the local level.

37. Technology transfer schemes should also recognize that ongoing technological development is often driven by commercial considerations, so that investment in further research and development can be properly funded. Nonetheless, the least developed countries that have not benefited from the increase in private capital inflow need special attention. To address this issue, priority could possibly be given to low-cost technologies and the use of local resources, including raw materials, that could be promoted as environmentally feasible.

H. Mobilization of financial resources

38. Developing countries face a daunting situation. Although the challenges of developing sustainable financing of traditional subsectors (such as urban water supply and irrigation) have yet to be met, they simultaneously face enormous financial, technical and institutional challenges in managing their water and land resources in a sustainable integrated manner. The quality of the intertwined land and aquatic environment is a concern in all countries, but in many developing countries, the situation is acute. This is most obvious in cities where sewage and industrial effluents are rarely treated. There are also very major problems associated with inappropriate land and water use in agriculture. The financial resources required to deal adequately with these problems are often beyond the means of most countries. While official development assistance is an important source of finance in the poorest countries, in most developing countries, the bulk of investments required to tackle these problems will have to come from national sources. In order for this to happen, Governments need to foster an enabling environment that encourages investments from both public and private sources, and to allocate a significantly higher proportion of their budget expenditures to public investments in sanitation and sewage treatment in order to control the adverse environmental health impact on both land and water ecosystems. This will often include measures to ensure cost recovery of improved service provision, as the Umgeni example clearly shows (see box 2). In fact, greater attention needs to be given to the use of economic instruments, such as pollution charges and taxes on fertilizers and pesticides, to control the discharge of industrial effluents and non-point sources of pollution in agriculture.

39. As discussed in a paper prepared for an expert group meeting on strategic approaches to freshwater management[2] held at Harare in January 1998, it is possible to identify two major approaches to dealing with environmental standards and the costs required to achieve those standards. The first approach can be characterized as the "set-the-standards-and-then-raise-the-money" approach. The prime example of this approach is the European Union, where the magnitude of investments required to meet standards is staggering. Germany, for example, needs to invest an estimated $300 billion if existing water quality standards are to be met. At current (high) investment levels, this would take 40 years to achieve. The second approach is one in which

Box 2. Umgeni water board: expanding access to improved levels of services through the private sector[3]

Umgeni Water, the largest water utility in the province of Natal, South Africa, takes a long-term view in the provision of water supply to a catchment of 24,000 km and a population of 5.5 million people, of which 1.5 million is rural. Development and growth has put the water resources under stress. The utility identified a major source of pollution to be from the discharge of raw and untreated sewage into the basin resulting from increased urbanization and informal settlements. In addition, soil erosion in the headwaters was causing increasing silt loads in rivers and reservoirs. As a result, the cost of water supply to urban users was increasing due to expensive treatment processes.

To counter these long-term effects, the utility started providing water supply to rural areas, also demonstrating that services could be provided jointly to rural, peri-urban and urban areas in a cost-effective manner, with full cost recovery for the operations and maintenance cost. The utility covered the capital cost by a capital subsidy from the urban to the rural areas, which – when a broader perspective is taken of the environment and long-term cost price relationships – is essentially seen to be of benefit to the urban dwellers. The utility charges households the full capital cost for house connections and recovers the full recurrent costs. Umgeni Water is a parastatal that receives no subsidy. It is triple A rated on the stock market and issues its own bonds.

environmental quality and the required financing are considered simultaneously. The origin of this approach was in the Ruhr basin in Germany at the time of the First World War; the approach was subsequently (in 1960) adapted by France on a national scale, and it is now being used in several developing countries. The new Brazilian water law, for example, incorporates many of the lessons of the Ruhr/French experience.

40. The Ruhr-French approach is based on a coherent set of institutional and instrument principles. The "institutional principles" are those of participation, subsidiarity and technical efficiency. With respect to participation, the French river basin financing Agencies provide a good model – 60 to 120 parliamentarians, representing all users and interested parties, choose the vector of water quality and cost appropriate for their basin, and decide on the assignment of costs among the public and private parties involved. With respect to subsidiarity, the basin agencies are careful never to do anything that can and should be done at a lower level, such as a municipality or irrigation district. Thus, although the basin agency decides on abstraction and pollution charges, it has nothing to say about whether a city chooses to have a public or private agency operate its water supply. With respect to technical efficiency, this model depends heavily on strong technical basin agencies, which ensure that basin management is scientifically and technically sound and advise the water parliament on the trade-offs between standards and costs, and on how best to deploy available resources.

Notes

[1] Robert Young, *Measuring the Economic Benefits for Water Investments and Policies*, World Bank Policy Paper, No 338 (Washington, D.C., 1996).

[2] John Briscoe, "The financing of hydropower, irrigation and water supply infrastructure in developing countries".

[3] Discussed in a paper by Ashok Nigam and Sadiq Rasheed, entitled "Financing of freshwater for all: a rights-based approach", submitted to an expert group meeting on strategic approaches to freshwater management, Harare, from 27 to 30 January 1998.